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The American Society for Testing Materials.

The convention of the American Society for Testing Materials, at Atlantic City, this week, demonstrated clearly that something must be done to prevent any further development along the lines of the last three years. When the program for two of the three days' meetings of a society with a field of such nominally restricted extent as this must provide for holding different sections simultaneously, it is manifest that some new departure in the way of meetings must be tried. Moreover, when some of the papers, few of which are printed for advance distribution, are presented only by title or in a very sketchy way in order to save time, the value of the oral discussion is inevitably curtailed through a lack of full appreciation of the papers by the audience. The utility of the society's work has become so widely recognized that its very success may become a cause of annoyance to the numbers who are interested, often deeply interested, in the subjects before two sections meeting simultaneously. An attempt to crowd too much into a three-day program is a hazardous proceeding. The sessions of this society are so earnest and often of such grave importance that by the time half of the program is carried out, the members become pretty well tired out.

The convention of this week indicates that if the society is to develop with the same rapidity that has characterized its past growth it will shortly become absolutely necessary to abandon the methods that were good enough for a small organization and adopt those of a large society. The change might take the form of two conventions each year, or the present bulk of the papers might be cut down within working limits by adopting the system of the American Railway Engineering & Maintenance of Way Association. Soon after this association was organized it was threatened by the same condition of overloaded program which is imminent with the American Society for Testing Materials; but it escaped by passing drastic rules concerning the subjects to come before it for discussion. As a consequence, instead of pottering around among a great variety of subjects, the attention of the meetings is concentrated on a comparatively few and these are thoroughly debated. Another change that ought to be made is the prior publication and distribution of the papers to be presented for discussion at the conventions. If a program of sixty-one papers and reports is to be carried out in six sessions, as was attempted at Atlantic City this week, good results can only be attained by distributing the papers in advance. This is not a serious task, as is witnessed by the fact that the American Water-Works Association, which has smaller resources than the American Society for Testing Materials, but publishes a volume of "proceedings" of about the same size, is able to issue most of its papers to the members a month in advance of their presentation.

The American Society for Testing Materials has such an exceptional position and record up to the present time that it is safe to expect the capable managers who are directing its affairs will devise some means of satisfactorily avoiding the danger of a surcharge of good things at future meetings.

Short-Span Railroad Bridges.

The difficulties encountered in the design and construction of long span railroad bridges are so obvious that much has been written about them. Careful studies in search of economic and efficient structural features have resulted in a rather abundant literature of long-span bridges, not only for railroad but also for highway traffic, of all types from the simple rectangular truss to cantilevers and stiffened suspension bridges of the greatest practicable lengths of span. In consequence of the comparatively great costs of long-span bridge structures, this is but rational. As a matter of fact, however, the prominent and rather spectacular character of the long-span bridge has diverted engineering attention from a most important class of structures at the other end of the line.

The short-span railway bridge is a structure of far too much importance to be neglected as a subject of engineering study. It is apparently a common every-day sort of structure requiring no special consideration and for which almost any simple type is good enough. This is far from the truth. The short-span bridge is required so often and must perform duties of such an intensely severe character that its suitable design is worthy of the most careful consideration. The number of spans below 75 ft. in length is so great on the railways of the country that it would be of interest to know how many times their aggregate lengths exceed the combined lengths of all the long-span structures.

The short-span bridge has for its lower limit of length the railway culvert, but its upper limit is not precisely determinable; it is probable that it should not be taken less than 50 ft., nor more than 100 ft. The best modern type of permanent construction can be carried up to either of those limits, not only with structural advantage, but also with economy. The rolled beam, formerly of wrought iron but now of steel, has been the standard type for many years for short spans up to about 20 ft., and plate girders above that to spans at the present time varying from 75 ft. to about 100 ft. in length.

The paper published a week ago in this journal on the short-span bridges of the Baltimore & Ohio R. R. emphasizes the fact that the standard type for such structures is changing most radically. It has been quite generally recognized for some years that the steel bridge is not a truly permanent structure. It is not far wrong to say that experience has shown the life of the iron or steel railroad bridge to be scarcely more than 20 to 25 years; not from any inherent lack of durability of the material but in consequence of the lack of its adaptability to sufficiently simple and massive design. The excessive cost of making a steel bridge heavy enough to carry the increasingly heavy traffic of a prosperous modern railway at the high speeds now required has been prohibitive. The old stone masonry structure was certainly simple and massive, but it also was too costly except for culverts.

The increasing cost of the steel bridge and the decreasing cost of the best modern masonry has afforded a most satisfactory solution of these conditions, as far as they affect short spans. One of the structural defects of ordinary stone masonry is its lack of toughness so that it is incapable of acting as a beam or girder. The modern masonry, reinforced concrete, is completely free from this objection and at the same time has the merit of a high degree of economy. It may be easily and rapidly put in place, either as a beam or an arch, with little or no skilled labor and with only that degree of care which is readily attainable in almost any field force of laborers. The amount of steel required is comparatively small, in shapes most readily produced in the steel mill and, at most, with a small amount of shop work. Fortunately, also, the steel is completely embedded in the surrounding concrete, the best preservative now known, so as to be absolutely permanent or durable without painting or any other corresponding attention.

The design of a reinforced concrete structure of any type is now so well understood as to lend itself to analytical treatment with almost the same degree of accuracy as an all steel bridge. The analytic simplicity of the reinforced concrete bridge constitutes a material advantage in the determination of the sectional areas of the main members, while the computations required at such great length for the details of the steel structure are almost entirely avoided.

There is no reason whatever why reinforced concrete railway culverts built as beams, supported on the side walls, should not be designed with the comparatively small amount of steel required by accurate computations. Close economy would require this procedure. At the same time if old rails are at hand in consequence of track renewals, solid and most excellent combinations with concrete may be made by using them, as has been done by the Baltimore & Ohio and other railways. For greater lengths of spans up to even 50 or 75 ft. reinforced concrete girders with solid floor of the same type can be advantageously designed, or reinforced concrete arches may be constructed up to almost any lengths desired.

This type of short span railway structure has the great advantage of absolute permanence with reasonable economy in every case of what may be called a short span bridge. It may be made sufficiently massive to take the increased moving loads for perhaps an indefinitely long future period and it is absolutely free from the great number of troublesome details of connections which constitute not only an element of cost in the steel structure but also features difficult to maintain in proper condition and which consequently are points of incipient weakness and deterioration.

A Government Armor Plate Plant.

People interested in the iron and steel industry must have been considerably astonished by the recent action of the House of Representatives in requesting the Secretary of the Navy to appoint a special commission to investigate the desirability of establishing a government armor-plate mill. There has been no exposure of frenzied finance in this industry by any of the yellow magazines, nor has any youthful novelist written a lurid tale of squalor and oppression among the employes of existing mills engaged in armor-plate production. In the absence of these customary provocatives of Federal investigations it was natural to assume some temporary immunity from this mentally bilious view of the highly specialized industry in question, but this assumption has been rudely shaken by the action of the House, which doubtless desired to show the public that it was still able to do something without asking permission of the executive department of the government. Fortunately for all concerned the investigation will not be made by people who do not know even the technical terms of what they will study, but will be in the hands of gentlemen whose opinions will merit careful consideration.

The manufacture of armor plate is a specialty at present attempted by but three companies, the Carnegie, Bethlehem and Midvale. Some years ago, when it was conducted solely by the former two, there was a belief that an agreement existed by which the prices were kept at an excessive figure, and an investigation of the desirability of constructing a government plant was undertaken. Nothing came of it, however, and the advent of the Midvale company as a competitor in the business was believed to have quieted the feeling that a government mill was necessary. The price charged for armor by the Carnegie and Bethlehem plants is about $440 a ton, while that of the Midvale company is about $398. The last company has only begun the production of such material, however, and whether it will continue to quote such a price remains to be seen. It is generally understood that if a steady demand for armor plate can be assured, $400 a ton is a good round price to pay, but with the inevitable uncertainty as to the market it has very little attraction at any price to most companies at the present time.

The assumption that the government can produce good armor plate at anywhere near its cost to the three companies which are now making it is based on a misconception of the difficulties of the work. A great mill must be constructed for the purpose, and it is safe to say that the government will find it very difficult to secure men able to design such a plant. There are very few of them and they draw salaries so far above the compensation paid to public employes that their services cannot be obtained. Even assuming that a good plant were constructed, the difficulty of obtaining the necessary skilled employes remains. It may be doubted if Congress would be willing to pay even half of the salary to the higher officials of such a plant which they can earn at present in private work. As for the workmen, it is only necessary to look at the manner in which the Government Printing Office is run to recognize that a government armor plant would speedily become so overstocked with high-salaried incompetents that an economical administration of the works would be out of the question. The private companies have a further advantage that would be wholly lacking in the case of government mills. In the other departments of their works they have thousands of skilled men and can choose for the armor department, where the best workmen are absolutely essential, the most competent among their great number of employes. The men the government can pick up will inevitably be the worst of their trade. Congress will not allow good wages, the labor unions will raise a row if the best is treated better than the worst, and there will be no incentive for an ambitious man. On the other hand, the certainty of short hours, assured pay at a better rate than poor men can earn with private mills, and the protecting arm of the unions to ward off the results of any little irregularities, will make a government mill a fair haven for just the class that private mills weed out of their service as fast as discovered.

If it were possible to be assured of steady running, it is not unlikely that the present ruling prices for armor plate would be somewhat reduced. In view of the fact, however, that such a certainty cannot exist, it is necessary to allow for periods of shut-down in such plants, and as their cost is great this stand-by expense is quite high. Moreover the manufacture of armor plate is a highly technical branch of the steel industry and the amount of waste in it is great if a company does not care to risk having some of its plates rejected. Consequently this product must always cost a high figure to turn out, even with steady production and reasonable requirements by the Navy Department. It is difficult to believe, however, that a government plant can produce as good plate at the same cost, even operating under the best conditions possible with federal direction.

The North River Crossing at New York.

There has recently been a renewal of public indications of the importance of the North River crossing between New Jersey and New York. In the first place, the New York and New Jersey Interstate Bridge Commission has begun its hearings on the location, character and terminals of the bridge which it is proposed to have built at the expense of the two States. The members of the commission are men of high standing, and it is reasonable to anticipate that their preliminary work will be done thoroughly and promptly. The one important fact about their work at the present moment is that the projected public bridge starts out with a better chance of being constructed than any of the previous projects, which were backed by private interests. One of these was promoted mainly by the Pennsylvania R. R. Co., but was allowed to lapse on account of the reluctance of other railways to join in an undertaking of such cost. A second bridge was apparently a speculative project, and was not laid on the shelf until the city refused to give permission for the approaches in the New York streets necessary to make it an attractive financial proposition. The second intimation of the importance of the subject is afforded by various semi-official statements concerning the studies being made by the Erie and Lackawanna railroads of the practicability of constructing tunnels under the river so that passengers can be landed in New York without any of the annoyances incident to the present system of ferry transfer. Although the air is thick with rumors of insurmountable obstacles in the tunneling operations of the Pennsylvania R. R. and reports of defects in some of the other tunnels under the North River, it is evident that railway officers in a position to know all the facts consider such rumors of no account. Otherwise they would certainly not be taking the preliminary steps, even in an unofficial way, toward such methods of crossing the river.

About six months ago it was pointed out in this journal that, with comparative suddenness, the engineering situation had changed so that any private enterprise for bridging the North River had little chance for a successful issue. This view is confirmed by the recent developments, the bridge project being a public undertaking of two States, while the private projects for a crossing contemplate tunnels. Except in the case of a mounmental structure, such as the joint-State bridge, the rule must be that the choice between a tunnel and a bridge will be decided on financial grounds. At the present time, the choice will generally be for the tunnel although it affords a line of communication far less agreeable than one above ground. Various methods of tunneling have been greatly developed, so that systems of construction have become simplified and made much more economical than formerly, at the same time materially enhancing safety, both in construction and operation. The tunnels completed recently in Boston and New York exhibit in a remarkabe manner not only great improvements in the design and use of shields but also the highly enhanced economy that has been reached in such construction by the use of compressed air. The process of forcing a shield through soft material as a mole forces its way through the ground, without excavating the material, is sufficient to account for the economy of some of the work done by Mr. Jacobs. Although this economy is exceptional, yet the standard use of the shield has been so far developed by improvements in design and by increased skill and efficiency in its employment that railway tunnels can now be built through any soft material at a reasonable expense where formerly their cost would have been prohibitive.

This technical reason for the increased favor for tunnels is by no means so important, however, as a financial one. A great bridge requires a relatively large area of ground for its approaches, and the higher the structure, as a rule, the greater will be this area. The cost of real estate is a serious handicap to a bridge project and one that has sometimes proved fatal where the land required for the purpose was already built up. The gravity of this matter is well shown by the expenditures made for the approaches to the bridge across the East River at New York. The approaches to a tunnel involve little or no expense for real estate unless it is desired to have them end in imposing office structures. The grades leading to bridges also present peculiarly difficult problems in many cases, while the tunnels under the North River are not seriously handicapped in this way.

There is one feature of the use of tunnels under the North River as railway entrances to the city which is receiving the serious attention of railway officers and may prove decisive, although very little has been said publicly about it. This is the matter of rolling stock. The results of even a small fire in a tunnel are too serious to be trifled with, and the careful attention paid to the subject by those responsible for the operation of tunnel roads shows they are fully alive to the gravity of such fires. It may be safely said that this is the most important feature to-day of the problem of handling large numbers of passengers under the North River by tunnel. The smoke from an insignificant fire would cause a stifling condition of the atmosphere and fatalities of a terrible nature. It is, therefore, incompatible with reasonable safety to passengers to run anything but strictly fireproof cars through such tunnels, which means a great expenditure for a special type of cars for suburban service. For example, if the Lackawanna R. R. would build a tunnel, it would either have to require passengers to change cars at the tunnel entrance or else put on an equipment of all-steel cars for its entire enormous suburban service. To run wooden cars in a tunnel or subway, as is now being done by the Interborough Rapid Transit Co., is to risk the lives of a great number of people in a manner that is not far short of reckless. The officials of some companies have already recognized this in their plans, and it is to be hoped that the cars on the New York Subway will all become of the fireproof type before a great disaster occurs.

Latest Developments in Sewage Disposal.

The comprehensive and authoritative article on another page on sprinkling filters for sewage treatment which has been written specially for the readers of this journal by Mr. George W. Fuller, furnishes information of exceptional value to those interested in the disposal of this class of municipal wastes. Very few engineers, even specialists, have had the author's opportunity of determining by research and personal examination of existing works just what are the possibilities of sprinkling filters. It will be noticed that even Mr. Fuller is careful to avoid definite statements of what they will accomplish when used under conditions not already tested by laboratory methods or by actual experience. This conservatism makes the article particularly valuable, for over-confidence in untried schemes has been the cause of many failures in sewage disposal plants. Just at the present time, moreover, when various cities are investigating this subject, a statement concerning it by a specialist of the author's standing should do much to assist public boards in understanding the actual status of these comparatively new methods of disposal.

It will be noticed that the septic tank and the sprinkling filter are not put forth as the equivalent of intermittent sand filters. For some reason difficult to understand, a few engineers seem to think that any recommendation of another system of disposal than intermittent filtration is a reflection on the latter as a strictly American institution, to be supported through thick and thin on all occasions and against all comers. This is not a correct view to take, for while it is probably true that intermittent filtration affords the most satisfactory method of treatment under many conditions, it has certain drawbacks that keep it from being a panacea. In fact, the rapidly widening range of definite knowledge concerning what may be done by different methods of sewage treatment indicate to some observers that intermittent filters are financially impracticable in a considerable part of the country, and even where they can be built and operated at a low cost the degree of purification locally demanded may render some other less expensive system a better one. The Engineering Record believes intermittent filtration to be the most effective all-round method of disposal yet given a fair trial, but it also believes that some of the methods developed lately will probably be found better suited for the conditions of a large number of cities. There has been rapid progress in developing recently our range of data on this subject, and while conservatism is warranted up to a certain point it is a mistake to deride everything new because the first attempts, often made with imperfect recognition of essential features, have not been wholly successful.

A very good instance of this last point is afforded by Mr. Fuller's statements concerning the odors from septic tanks. There have been tanks so offensive as to be almost sickening, while others give off no odor or not so much and that not so offensive as can be detected in a theatre on a warm night. Specialists who have examined the subject have assured this journal that there was no reason for any pronounced odor, but Mr. Fuller's detailed statement on the subject is probably the first explanation yet published concerning it. It is, in effect, that the capacity of the tanks is not suited to the quantity and character of the sewage reaching them and that the removal of the sludge is not done in the proper manner. For the details of these criticisms the reader is referred to the article, but attention is called to them specifically because some engineers have laid a wholly unwarranted stress on the odors given off from a few tanks as a reason for using intermittent filters on every occasion.

On the subject of the cost of treating sewage by intermittent filtration and by methods of later date, anything that can be said at the present time is merely a repetition of what has been said before. It is true that the new systems involving septic tanks and coarse-grain filters require more careful supervision than the intermittent filters, although the latter can by no means be left to work out their own salvation and that of the sewage discharged over them. This added complexity of management which the new methods of disposal entail is the inevitable accompaniment of progress, as was pointed out years ago by Herbert Spencer. Simplicity is desirable, but it is not everything, and true progress is concerned with the end to be attained and its cost, not the steps by which the end is attained. Nevertheless, what is good for one community, willing and able to spend money for the best system of works, may not be best for another, perfectly willing to build the best, but decidedly unwilling to pay for efficient management. On this account every new and successful method of meeting a problem must be welcomed and not derided as a rival of some pet system of limited usefulness.

Notes and Comments.

THE HARBOR IMPROVEMENTS at Fishguard, on the Welsh coast, will be so far completed in a couple of months that the port will probably be opened in August. To American engineers, accustomed to government construction of harbor improvements, this large undertaking of the Great Western Ry. seems an unusual piece of private enterprise. Over 2,000,000 tons of rock have been moved, a commodious railway station, electric cranes, power house, and marine depot, and 6 miles of sidings have been built, together with powerful breakwaters and sea-wall galleries for landing cattle. The new harbor is surrounded on three sides by high hills, two bold headlands 6 miles apart marking the entrance to the bay. It is expected to make Fishguard a port of call for ocean liners from Canada, the United States, South America, Australasia, and eastern ports, bound for Liverpool and Glasgow, as well as providing a new quick route from London to Ireland.

A REMARKABLE BUILDING is to be erected at the corner of Wall St. and Broadway in New York. Its site is the costliest in the country and probably in the world. The lot measures only 29.1 x 39.1 ft. and has an area of but 1,170 sq. ft., yet it cost the present owners $700,000. The building will be eighteen stories, or 235 ft. high, and each floor will be rented as a whole, so that none of the precious space will be taken up by halls. The average rental for the building is understood to be about $5 per square foot. Three 4x5-ft. elevators will be employed, opening directly into the office of the tenant on each floor. The ground floor and basement, having a total area of but 1,568 sq. ft., have been rented for a cigar store for $40,000 a year, or about $25.50 per square foot. The building is a remarkable example of the manner in which steel-cage construction is able to utilize the full value of a small lot; fifteen years ago, before such buildings and their elevator equipment had been thoroughly perfected and tested, the idea that a $700,000 investment on a little plot of ground could be made profitable without buying more property would have been laughed to scorn.

THE MUNICIPAL ENGINEERING SOCIETY recently organized in Philadelphia among the members of the various city departments deserves to have a successful career. The purposes of the organization are "to elevate the standard of efficiency and harmonize the work of the engineering staffs of the several departments of the public service and to promote the arts and sciences connected with engineering by means of periodical meetings for the reading and discussion of professional papers." A similar association in New York has been of distinct advantage to its members and to the city, and the same should be true in all other cities so large that engineering work done in them is subdivided between departments having but little official intercourse. The greater the city the more desirable it is for the engineering staffs of the several departments to know and appreciate all the difficulties that are arising and to be acquainted with the methods and useful processes originating in any one of them. Moreover, the acquaintanceship between all the engineers which will be formed in this way will do much to diminish the friction and jealousy that is too often seen in large organizations.

EFFLORESCENCE ON BRICK WALLS has been investigated by Mr. J. C. Jones, of the University of Illinois, who finds the causes of this unsightly appearance to be: 1, Soluble salts contained in the clay as mined. 2, Soluble salts developed in the clay by weathering. 3, Soluble substances formed in the clay during burning, partly by chemical changes among the ingredients of the clay itself, and partly by interaction between the materials of the clay and kiln gases. 4, Soluble salts in the mortar used to bind the bricks in the wall. 5, Soluble substances developed by reactions between the ingredients of the mortar and those of the clay. 6, Soluble salts in the water used in the manufacture of brick or mortar. 7, Soluble salts in the soil or substances lying against the wall. He finds that efflorescence usually is made up of sulphates and carbonates with occasionally salts of other acids which are carried to the surface of the bricks by the evaporation of water which has entered them. The suggested cures are: 1, The use of clay which has not been weathered. 2, To weather the clay and then wash out all soluble salts. 3, To change soluble into insoluble salts by introducing some precipitating agent as barium. 4, To remove efflorescence which has been formed in the kiln by alternating oxidizing with reducing conditions during the latter part of the burn. 5, To coat the bricks as they come from the machine with some organic substance. 6, To burn the bricks so that they will absorb the smallest possible amount of water. 7, To coat those portions of the wall below the ground with waterproof paint. 8, To see that the gutters and flues which carry water or steam pipes are so constructed that water cannot reach the walls. 9, To make mortar joints as thin as possible, and use mortar which is free from sulphur or nearly so.

NOTES ON SPRINKLING FILTERS FOR SEWAGE TREATMENT.

A Résumé of American and Foreign Experience.

By George W. Fuller, M. Am. Soc. C. E., New York.

Recent developments in this country indicate clearly that sprinkling filters are to have a prominent position here in the field of sewage purification. The construction of a 20,000,000-gallon filter of this type at Columbus, Ohio, as a result of extensive local investigations based upon and supplementary to earlier Lawrence tests was an important step in the introduction of this class of filter under American conditions. Another such step was the recent recommendation of the Board of Advisory Engineers at Baltimore to install sprinkling filters for purifying the sewage of that city. The Baltimore recommendation is especially important in emphasizing the practicability of sprinkling filters, in view of the fairly porous sand areas not far distant, although it is true that these areas within some six or eight miles of the city contain considerable clay mixed with the sand.

Historical Notes.—Historically, sprinkling filters, and indeed all sewage filters of coarse grain material, are the outcome, scientifically, of experiences of the Massachusetts State Board of Health with gravel filters at Lawrence, commencing in July, 1889. At first these gravel filters, some of which contained material of a size ranging from 0.25 to 0.75 inch, were operated at about such rates as employed with intermittent sand filters. The early results were not particularly encouraging principally due to the passage of the sewage too quickly through the filters. This was remedied to a large degree by applying the sewage at about 20-minute intervals from small receptacles automatically discharged by a siphon. The original gravel filters at Lawrence, however, became so clogged with suspended matters in the unsettled sewage that they never attained marked success. These filters at Lawrence were reconstructed with new gravel in 1892, and for a period of over three years gave quite satisfactory results when operated at a rate of nearly 500,000 gallons of raw sewage per acre daily. When viewed in the light of our present knowledge it is seen that these filters were not sufficiently provided with underdrains, and their utility was obscured to a considerable degree by the clogging caused by the suspended matter in the applied sewage. Efforts were systematically made at Lawrence, beginning in 1893, to overcome this clogging by providing a circulation of air through the filtering material by forced draft. This method, which was tried in England by Lowcock in 1892 and by Waring in 1894 at Newport, was helpful but prohibitively expensive.

It was the English engineer who developed the modern sprinkling filter in its practical form. Following the publication in May, 1891, of the results of the first two years' investigations at Lawrence, there were commenced a number of notable series of experiments abroad upon sewage purification. Of all of the Lawrence studies, those which attracted by far the most attention in Europe were the results obtained with the gravel filters referred to above. The foreign experiments which seemed to have most to do with the sprinkling filter development, as now understood in this country, were made at Salford, England, under the direction of Mr. Joseph Corbett, Borough Engineer. He quickly appreciated the importance of applying the sewage to filters of coarse material in such a way that an opportunity would be offered for purification of the sewage during the fairly short period of travel from top to bottom. This he provided for by spraying the sewage on to the filter. He states that this idea occurred to him from noting the local practice at various mills of discharging water into cooling ponds through spraying nozzles partly for cooling and partly for aerating the water, which was used over and over again.

Types of Coarse-Grain Filters.—There are a variety of ways for applying sewage to filters of coarse material. The method which has until recently been most widely used is that of contact filters, by which the pores of the material are filled and then, after a short period of rest, the contents are slowly drained. This method was developed by Mr. Didbin, then Chief Chemist of the London County Council, in a series of experiments at Barking begun in 1892. A comparison of contact filters with sprinkling filters from the standpoint of efficiency and economy is given beyond. Contrasted with contact filters there are numerous methods of applying sewage to coarse-grain filters, either as small doses at frequent intervals or as continuous doses from numerous points of distribution. Naturally there have arisen numerous names for the filters. For several years frequent use was made of the expressions, "continuous intermittent filters," "percolating filters" and "trickling filters." As this general style of filtration has advanced it has been recognized that there is needed a more distinctive name than that of "continuous intermittent filters," which seems to be dropping out of use. "Percolating filters" is an expression which has obtained quite a strong foothold in England, but in America it is used by only a few, owing to the fact that "filtration" and "percolation" are practically synonymous terms in the language of many if not most engineers and laboratory men. For this reason it seems quite certain that in America "percolating filters" is too indefinite an expression to come into general use.

"Trickling filters" seems to be the best general name characteristic of these coarse-grain filters which do not come under the head of "contact filters." This term is descriptive, as the sewage actually "trickles" over the surfaces of the coarse material of the type of filter under consideration. In some cases abroad and in a few cases in this country, sewage is applied to coarse-grain filters by means of tipping trays, notched or perforated troughs, and siphonic discharges, either into manifold piping with a series of fairly large orifices, or through open-jointed distributing pipes either on or below the surface. It is also applied through grips or trenches of fine material either with or without siphonic discharge. For all of these methods, including the sprinkling filter itself, it is believed that the general name of "trickling filter" is most suitable. Of the several subdivisions of "trickling filters," the present indications point to the use of sprinklers as the most feasible method to apply sewage to filters on a large scale. In England this is done either through a series of revolving pipes with suitable perforations or by a series of jets from which the sewage is thrown in the form of a spray quite similar to the action of certain lawn sprinklers. For American conditions the traveling sprinklers, whether revolving over circular beds or whether moving backward and forward by independent motive force over rectangular beds, seems to be precluded from general use, owing to the severe winter weather in the Northern States. In the South they are applicable. Available evidence indicates, however, that at present the best method of applying sewage to coarse-grain filters is from fixed sprinkler nozzles with comparatively large orifices, in a manner resembling the design adopted at Columbus. These nozzles will not freeze during zero weather, although occasionally accumulations of frozen sewage upon the surface of the filter may become more or less bothersome. This in fact is the distinguishing feature of what is now considered the most suitable form of coarse-grain filters for general American conditions.

Sprinkling Filter Installations.—In America no sprinkling filters have as yet been tried on a large scale, and the nearest approach to such practical experience is that at Madison, Wis., where sewage is applied to cinder beds from a tank discharged intermittently by a siphon through a series of perforated pipes placed quite near together beneath the surface. Experimental evidence on sprinkling filters in America is quite extended and decisive on many of the more important features. At the Lawrence Experiment Station of the Massachusetts State Board of Health, ten filters of this general type, to which sewage is applied with tipping trays, have been tested during the past seven years, some of them for the full period. At Columbus, Ohio, six experimental sprinkling filters were tested for a period of about ten months, as described at length in the recent report on sewage investigations made at that city. Since early last autumn filters of this general type have been tested at the testing station of the Massachusetts Institute of Technology, Boston, and at the testing station of the City of Waterbury, Conn. These various tests with the ten-acre plant now under construction at Columbus, Ohio, and the thirty-acre plant recommended for Baltimore, constitute the main evidence on, and general standing of, this type of filter at present in America.

In Europe there are numerous sprinkling filter plants in service and under construction. The largest community to adopt this type of filter is Birmingham, England. This city, with its suburbs, makes a metropolitan district of about 900,000 people. It had in regular service at the beginning of 1906 an area of 6.5 acres of sprinkling filters. Additions are being systematically made and it is expected that the plant will be more than doubled in size by the end of this year. Salford, England, after some extended experiments, adopted this type of filter and commenced construction in 1899. The filter plant, which went into service in 1902, has since been extended in area to 7.5 acres. At each of these places the sewage is distributed from fixed sprinkler jets or nozzles. In 1898 revolving sprinklers were introduced at Accrington, which, with the neighboring town of Church, has a population of about 50,000. The total area of filtering surface is about 15/16 acre. Another similar plant which has done successful work is that at Hyde, which has a population of about 35,000. At Hanley, England, a six-acre sprinkling filter plant is approaching completion. These beds are rectangular in shape and the sewage is applied by a traveling sprinkler operated by an electric motor and cables. The sewage enters the perforated distributing pipe, which spans the bed from troughs extending lengthwise of the bed on either side. At Huddersfield, England, a 10.5-acre sprinkling filter plant with revolving distributors was placed under contract last winter. Extensive experiments upon this and other types of sewage purification have been conducted at Leeds, Bradford and York, and it is understood that land has been purchased and plans are being prepared with a view to the installation of this type of filter at an early day. These are some of the larger sprinkling filter projects in England, but there are numerous other works now built or projected containing many interesting features, which it is out of the question to mention here.

In France, the Department of the Seine has recently acted favorably on the recommendation of its engineers to adopt sprinkling filters for a portion of the first installation of a plant for purifying the sewage of the suburbs lying to the south of Paris. This plant will be located at

Creteil and the effluent will flow into the Seine just below Choisy le Roi.

In Germany, sprinkling filters have been tested at ten or a dozen different places. The sewage is distributed in the majority of cases either by revolving sprinklers or by graded surface layers of fine material resting upon the coarse filter bed. The latter procedure is known as the "Dunbar method," and it has been tested very thoroughly by Prof. Dunbar at Hamburg. It is in practical use at Unna and elsewhere. Various official documents, particularly those of the Royal Prussian Testing Station, set forth the German evidence upon modern filters. The influence of this station has been unusually far-reaching in assisting local authorities. An interesting feature of it is that it conducts tests for cities under arrangements by which a substantial portion of the expenses of the tests is met locally. The largest community to decide upon the construction of sprinkling filters in the city of Wilmersdorf and other suburbs lying to the south of Berlin, having an aggregate population at present of about 200,000 people. The cities of Leipsic and Chemnitz are at present conducting important tests on this type of filter.

Field of Sprinkling Filters.—Sprinkling filters, like all filters of coarse material, have their principal field of usefulness in purifying sewage to a point where it will no longer be putrescible. By that is meant that the organic matter in the sewage is reduced to a point where putrefaction and its attendant bad odors will not result when the treated liquid is exposed for several days to the temperature of the hot summer sun. They have quite an advantage over other types of filters because of the thorough aeration which the sewage receives before reaching the filtering material. With effective spraying nozzles the applied liquid contains about 80 per cent. of the oxygen necessary for saturation.

Where drinking water supplies or shell-fish pollution need not be considered it is quite generally recognized now that it is sufficient to purify the sewage so that the resulting effluent will be non-putrescible and of satisfactory appearance. It is not necessary to reduce the crude organic matter to such a low point that the remaining organic matter by itself is stable. But it is necessary to eliminate organic matter so that the effluent as a whole is stable.

Nitrification is always desirable, and within certain limits seems very helpful, but it is not necessary to secure as high a degree of nitrification as was thought to be the case a few years ago. The so-called "putrescibility test" in the analysis of sewage effluents, as compared with the oxygen consumed and the albuminoid ammonia tests, has a great practical advantage in showing the balance between the crude organic matter on the one hand and the oxygen available from atmospheric oxygen and nitrates on the other. So long as the amount of available oxygen provides a sufficient margin to allow bacteria to consume the remaining crude organic matter in the sprinkling filter effluent the latter may be considered to be satisfactory so far as elimination of nuisances is concerned.

Where drinking water supplies and shell-fish pollution are involved, however, it is, of course, a question of bacterial removal which, with sprinkling filters 8 to 10 feet deep and appurtenances, can be made equal to 95 to 99 per cent. of the bacteria in the raw sewage. With 5-foot filters the total removal is in the neighborhood of 90 per cent. Usually bacterial growths obscure the degree of bacterial removal, but hygienically such growths can apparently be ignored as they do not relate to disease germs.

Filtering Material.—As to the size of filtering material the majority of experiences in this country have been obtained with material of a size ranging from about 0.5 to 2.0 inches. Some of the older experiments at Lawrence were made with material ranging from 0.25 to 0.75 inch. The latter size is about that which has been studied at Salford, England, while at Birmingham, England, the material is very uniform in size, averaging about one inch or a trifle larger. The majority of experiences abroad, however, have been obtained with what is called "fist size" material. At Huddersfield, where the most recent large contract has been let for sprinkling filters, the material will have a size ranging from 1.5 to 6.0 inches and a depth of 6 to 7 feet. This will be passed through a 3-inch screen and the coarser material will be placed in the bottom of the filter and the finer on top. At Hanley much experience has been obtained with "saggers," which is a crushed refuse from pottery works, of a size ranging from 0.25 to 0.125 inch.

So far as purification is concerned, the fine material appears to give satisfactory results, but further information will be necessary before the best practice, all things considered, can be shown to lie with the fine material. It is apparent that the total surface area of filtering particles in a 2-foot bed of such fine material as used at Hanley will equal or exceed that of a 10-ft. bed of coarse material.

Construction costs per unit area of filtering surface will be materially less for the shallower bed of fine material than for coarse beds of greater depth. With the latter it seems certain that with good construction and management, sprinkling filters need not be cleaned from top to bottom oftener than once in 10 to 15 years, and many engineers abroad have come to the conclusion that the filters are permanent, requiring no cleaning whatever, except what can be accomplished by resting and distributing the surface by raking. With filters of fine material the suspended matters in the applied sewage are retained within the filter to a far greater extent than with coarse filters. This means that the effluent of the former is clearer and probably will not require settling, as is the case with the effluents of the latter. It also means that filters of fine material may require cleaning from top to bottom every few years, possibly every few months under some conditions where the load approaches that of filters of coarse material. How the greater construction cost of the latter compares with the greater operating cost of fine filters, when the amount of work done is about the same in each case, cannot now be stated definitely. Indeed, it is the chief problem yet to be solved for sprinkling filters under American conditions, and it will require careful tests conducted so that the filter material is the only variable quantity. Theoretically, the best size is as fine as will readily assure a vertical circulation of air through the filter and the associated function of unloading stored material as described beyond. For Baltimore the Advisory Engineers recommended 9-foot filters of material which will pass through a 3-inch ring and from which are rejected all particles passing through a 1.5-inch ring.

Coke, conders, slag and broken stone have all been used for sprinkling filters. It is certain that the material selected should not break down through continued use, and American engineers have thus far shown a preference for broken stone on the ground of greater permanence. It is true, however, that materials with a rough surface are somewhat more efficient than materials having a fairly smooth surface, especially when the filters are new. As the filters grow old this difference seems to slowly disappear.

Suspended Matter.—According to experiences with the sprinkling filters which have been longest in service, that is, from 6 to 8 years, and of medium and coarse material, their most striking characteristic is that the amount of suspended matter in the effluent approximates that in the applied sewage. There is, of course, some removal of suspended organic matter through oxidation and nitrification, and there is also a marked difference in the character and appearance of the suspended matter in the effluent and in the influent.

In the neighborhood of one-half of the finer suspended particles appears to pass through the filter from top to bottom quite promptly. This percentage varies materially with the roughness of the filtering material, rate of filtration and depth of bed, etc. Much of this suspended matter is of an extremely fine character, probably as small as or smaller than the bacteria and certainly not responsive to the laws of subsidence under existing conditions. This is the material to which has been applied the term "colloid" and which is called by some a "pseudo-solution" or a "sub-microscopical suspension."

These extremely minute "colloidal" particles which regularly appear in the effluent are associated with quite large masses or aggregates of suspended matter. The latter, existing in the applied sewage as numerous individual particles varying widely in size, become lodged on the surface of the filtering material in the form of films, which at intervals are detached and pass out with the effluent. Usually these relatively large masses of suspended matter in the effluent are either non-putrescible or nearly so. They are dark colored and unsightly, however, making it highly desirable that the effluent should be freed from them by passing through sedimentation basins holding a few hours' flow.

This power of coarse sprinkling filters to "unload" stored material in a manner so that it can be easily deposited and disposed of on land without trouble from odor is one of the great practical merits of this type of filter, and from the standpoint of economical operation places it far in advance of the contact filter or any other type of coarse-grain filter. In view of this function of these filters of large material, engineers will be loath to sacrifice the power of sprinkling filters to "unload" stored matter, although it is definitely assured that very shallow layers of finer material produce greater clarification and equal removal of bacteria and organic matter. The greater cost of maintenance of the shallow filters of fine material and less construction cost is an important matter for practical consideration. How this balance will come out cannot be told, as already stated, until after further data are available.

Depth of Filters.—Generally speaking, sprinkling filters range in depth from about 5 to 9 feet, although there are some cases which fall both below and above this range. The majority of filters now in practical use are from 6 to 8 feet in depth and 7 feet is about the average depth. The ability of sprinkling filters to purify sewage seems, within certain limits, to be proportional to the volume of filtering material, and as it is obviously cheaper per volume of material to build deep rather than shallow beds, the tendency seems to be towards the deeper beds as a rule. Hygienically, the deeper beds also have an advantage in effecting a relatively greater percentage removal of bacteria, other things being equal.

There are some cases where topographical conditions and other factors make it preferable to keep the beds to a depth of 5 or 6 feet. This was true at Columbus, where the beds will be of a depth of 5 feet. From what has been already said it is obvious that the size of material bears upon this question. It is important to have the filtering material placed upon a false bottom arranged to facilitate so far as possible the removal of the detached films from the filtering material. From time to time, as required, there should be removed such material as becomes lodged in the lower portion of the filter below and around the false bottom. Otherwise suitable aeration of the filtering material is not permanently secured, and it is only a question of time when clogging will begin at the bottom and extend upward. Another reason why coarse material is generally preferred abroad is that it largely eliminates the clogging effect of vegetable growths which frequently appear upon the surface of sprinkling filters and which may prove bothersome when the material is too fine. They can be removed, however, by allowing the filter to rest and dry out, and by forking over the surface.

Rate of Filtration.—As to rate of filtration it is difficult to state this briefly in comprehensive terms, as it depends to a considerable extent upon the strength of the sewage, size of filtering material, depth of filter, etc. Within certain limits it is also feasible to secure good results at the same total cost by varying the rate of filtration or capital charges on the one hand, and the operating expenses on the other. That is, the two variables tend to compensate each other.

At Columbus, where existing sewers are on the combined system and the later sewers will be on the separate system, 5-foot beds are estimated at a net capacity of 2,000,000 gal. per acre daily. At Baltimore, with separate sewers, the rate is estimated at 2,500,000 gallons per acre daily with 9-foot beds. In each instance the dilution of the sewage is expected to approximate about 125 gallons per capita daily.

The best general statement of American conditions at present appears to be that for 5-foot beds a population of 20,000 per acre may be served where the sewers are on the combined system, and assuming that the sewage applied to the filters is clarified in basins affording a sedimentation period of at least 6 hours. When there are separate sewers, this population may be increased somewhat unless it is desired to secure a somewhat higher degree of purification than that affording a non-putrescible effluent. With beds deeper than 5 feet the population per acre may be increased or a higher purity of effluent may be secured, as found most desirable under local conditions. Until the best size and depth of filtering material is more clearly established, it is fruitless to attempt to make more definite general statements as to rates for American conditions.

In England, where the sewage flow in dry weather usually equals 30 to 40 U. S. gallons per capita daily, there are several instances where one acre of sprinkling filter serves 30,000 to 50,000 people connected with combined sewers. During dry weather the rate on 6 to 8-foot beds is usually about 1,200,000 U. S. gallons per acre daily. During and after storms these filters must treat up to three times the dry weather flow where there are combined sewers and twice this volume with separate sewers.

In Germany, where the sewage is fully as strong as in England, the permissible rates of filtration are stated to range for 8.3-foot beds of fist-size material from about 1,250,000 to 2,500,000 U. S. gallons per acre daily, depending partly upon the thoroughness of preliminary treatment and partly upon the degree of purity of effluent which is sought. The higher rate above stated is intended to apply when the sprinkling effluent is subsequently filtered.

Trade Wastes.—Where trade wastes in considerable quantity enter the sewers it is necessary, of course, to give special attention to the requirements of each individual case. There appears to be no well defined rule as yet to serve as a guide in this regard, although in a general way it seems fair to adjust the population per acre on the basis of equivalent amounts of total organic matter so that the work done approximates that with domestic sewage along the line already indicated. In estimating these equivalent amounts in domestic sewage and in manufacturing wastes, it appears that for each person connected with the sewerage system there is a daily average addition of about 15 grams of total nitrogen and 30 grams of oxygen consumed.

At several places in Europe spent dye liquors when well mixed with sewage produce a dark colored effluent, and there are several cases where certain spent dyes maintain their individual color in the sprinkling filter effluent. Under some such circumstances highly colored sewages can be satisfactorily purified by sprinkling filters only with the aid of chemical precipitation.

Preparation for Filtration.—As to the preparatory treatment of domestic sewage and sewages containing street wash and fairly small quantities of trade wastes, there seems to be little or no question about the septic tank being the most suitable form under ordinary American conditions. The capacity of the tanks, however, according to present evidence ought not to exceed 8 to 10 hours' average flow, as it is highly important to guard against septicization of the sewage itself as it flows through the septic tank. When this is assured, there seems to be no material difference as to odors when the sewage applied to the filters comes from septic tanks or plain sedimentation tanks.

So far as the sprinkling filters are concerned there is no advantage in the septic treatment over that afforded by plain sedimentation when the degree of clarification is the same. In passing, it may be stated that the advantage of the septic treatment consists almost wholly in the ability to dispose of the sludge in largely reduced volumes and in a state where it has passed through the putrefactive stages and can be applied to land without offensive odors.

Speaking generally, a plant comprising septic tanks and sprinkling filters should, when well operated, produce no odors which ordinarily are noticeable beyond a few hundred feet. As a matter of precaution, however, it is wise to provide an area about ¼ mile in width between the works and dwelling houses or frequented roads. At Birmingham and other important places abroad it has been demonstrated that no objectionable odors are to be contended against. In midsummer during very dry weather, however, there are a number of works in England where the sewage becomes oversepticized and objectionable odors are encountered at distances of more than ¼ of a mile from sprinkling filters. Experiences of several years at Plainfield, N. J., Mansfield, Ohio, Saratoga Springs, N. Y., and other places show clearly that there is far less likelihood of trouble from odors with the dilute American sewages than there is with the strong English sewages. The latter contain so much suspended matter per unit volume that to provide sufficient space for storing the deposited sludge the septic tanks frequently are made much too large to guard against septic action in the sewage itself. When this is better understood at each plant, operations will no doubt be conducted so that the results will be uniformly satisfactory.

Another important feature about septic tanks which is not generally understood is that the sludge should not be removed until the organic matter has passed through the putrefactive stage and become inert humus matter. To accomplish this end, as is the case at Birmingham, England, and Mansfield, Ohio, it is helpful to shut off the influent for some days prior to emptying the tank.

Operation of Filters.—As to the operation of sprinkling filters the larger works will no doubt be provided in this country with devices for operating them from central houses and in a manner somewhat similar to the modern mechanical filter plant as built on a large scale. The labor for attendance will thus be reduced to a comparatively small item. In addition to this attention there will, of course, be required labor at irregular intervals for seeing that the sprinkling nozzles do not become clogged by deposits in the distributing pipes or by vegetable growths. The distributing pipes themselves must be flushed out from time to time so that the aggregation of fine particles will not accumulate to an undesirable extent. It is also necessary from time to time to clean out the underdrains around and below the false bottom either by flushing or by jointed swabs.

At intervals of 10 to 15 years under ordinary conditions it now seems wise to estimate that there will be required complete cleaning of the filtering material from top to bottom. This has already been done in several places in England with contact filters, which have been in service for from three to five years. It has perhaps been most systematically developed at Burnley, England, where, with labor at 12 cents per hour, it has cost about 25 cents per cubic yard to remove material from the beds to portable washing machines upon the bank, and to wash and replace it. This cost includes everything except interest on the washing plant and the purchase of new material to replace that lost in washing. In this instance the material was clinker; with a firm, hard rock the loss in washing should be trifling.

Cost of Sprinkling Filters.—The construction cost of sprinkling filters depends principally upon the depth and price of the filtering material. A 5-foot filter with connecting conduits, gatehouses and all immediate appurtenances, but exclusive of septic tanks and settling tanks, costs usually from $30,000 to $35,000 per acre. A 9-foot filter at Baltimore with broken granite brought from quite a distance was estimated to cost about $50,000 per acre.

Operating expenses at Baltimore for a 75-million gallon plant were estimated to be $2.20 per million gallons, including care of septic tank and also of settling tanks for the sprinkling filter effluent, but exclusive of capital charges. This is equal in round numbers to 10 cents per annum for each person connected with the sewers, which are to be on the separate system. With combined sewers the street wash would no doubt increase this operating cost somewhat, and large quantities of trade wastes would probably increase it still more. The expense of the latter is especially felt in the preparatory treatment. For plants smaller than the one at Baltimore the per capita cost of operation would be greater, especially for the item of attendance. In none of the above figures are pumping charges included either for the sewage, effluent or sludge.

Present evidence indicates that sprinkling filters can satisfactorily operate with American sewages at rates of filtration from three to four times as high as contact filters, other things being equal. In England this ratio appears to be about double for sprinkling filters. Operating expenses are greater for contact filters than for sprinkling filters. Contact filters will no doubt continue to be used in many small installations for one reason or another, but for large municipal work it now seems that their usefulness in this country will be confined to those places where their shallower beds enable the works to be operated by gravity while sprinkling filters might require pumping. Sprinkling filters with shallow beds of fine material may later cause these views to be modified as to necessity of pumping.

Photographing Blue Prints can be done very successfully, according to Mr. H. H. Suplee, by first bleaching the print in a dilute solution of ammonia, and then immersing it in a weak solution of tannic acid. This will bring out the drawing in non-actinic red, and a photograph of it will give a negative having black lines on clear glass. This can be backed with white paper and used for copy in the photo-engraving process.

Track Elevation at Chicago on the Pittsburgh, Ft. Wayne & Chicago Ry.

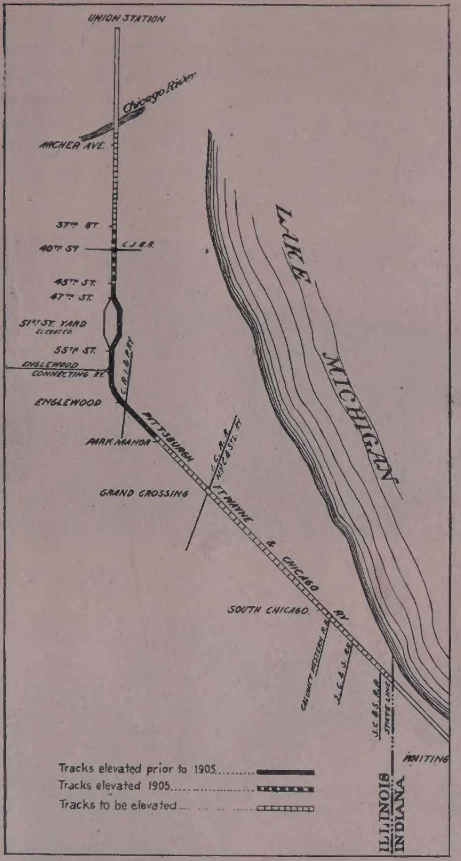
For a number of years, the Pennsylvania Co. has been engaged in elevating its tracks in the city of Chicago. It is thought the methods employed during the past season may prove of interest on account of the height to which the tracks were raised, and of the narrow space in which work had to be done. The Pittsburgh, Fort Wayne & Chicago right-of-way is hemmed in by the Chicago & Western Indiana right-of-way on the west and Stewart Ave. on the east, and is about 60 ft. wide. This space was occupied by four tracks, except for a short distance, and a retaining wall which had been constructed before any filling took place. During construction, it was imperative that traffic should not be delayed, and, therefore, necessary that two tracks should always be kept in condition for the regular traffic.

The ordinances for track elevation in the city of Chicago provide for the elevation of the Pittsburgh, Fort Wayne & Chicago tracks and the consequent elimination of all street crossings at grade from the South Branch of the Chicago River to the Indiana State Line, a distance of 12.89 miles. This stretch is shown in the accompanying map, which also shows the track elevation work done previous to 1905, that done during 1905, and the work remaining to be done. It should be noted that the work between 47th and 55th Sts. included the elevation and entire rearrangement of a large yard as a gravity switching yard. This work was practically completed in 1904. At the close of the season in 1904, the tracks had been elevated from a point south of the Englewood Station, at 63d St., to 45th St., where a 1 per cent. run-off had been constructed to reach the old grade at 43d St. Thirty-fifth St. is at present carried over the tracks on a steel viaduct, and is to be replaced by a subway. It was decided not to cut out this crossing in 1905, on account of risk of its remaining closed through the winter, and it was, therefore, decided to extend in 1905 the elevation work from 45th to 37th St., with a run-off to 35th St. At 40th St., the tracks are crossed by four tracks of the Chicago Junction Ry., and in order to abolish this grade crossing, it was necessary to raise the Pittsburgh, Fort Wayne & Chicago tracks about 23 ft., to provide the necessary clearance.

The grading, masonry, street work, trestles, and the erection of the steel superstructure were performed by contract. All track work was done by the regular organization of the Maintenance of Way Department, and a carpenter gang from the same department put in all stringers for abutment foundations, assisted in jacking up trestles as the grading progressed, and maintained all trestles under traffic. The regular track gangs were also used for constructing the cribwork for retaining the sand filling where needed.

The retaining wall along the east right of way line was started in 1904, and this wall was built between street crossings from 43d St. to 23d Pl., gaps being left wherever industrial sidings left the right-of-way, and in one or two places, where there were right-of-way complications. At the same time, foundations for abutments at street crossings were put in wherever possible, the tracks being carried on stringers during this construction.

Before starting work in 1905, an agreement was made with the Chicago & Western Indiana R. R. Co., by which the Pennsylvania interests obtained the use of the easterly track of the company for the first part of the season, and in return that company obtained the use of two of the P., F. W. & C. Ry. tracks later on, for an equal number of track days. Under this agreement, the main line traffic of the P., F. W. & C. Ry. was diverted on May 18 to the westerly P., F. W. & C. track, and the easterly C. & W. I. track, this traffic being then handled as per plan "B" in the accompanying diagram, and the three easterly tracks of the P., F. W. & C. Ry. were abandoned for construction purposes.



Scheme of Track Elevation.

At 40th St., through the courtesy of Mr. J. B. Cox, chief engineer, the Chicago Junction Ry. Co. operated across the rights-of-way of the P., F. W. & C. and C. & W. I. with two tracks during the period of elevation. The north and south tracks of this company were, therefore, abandoned and removed, and the two center tracks were spread to permit of trestle bents being placed between them. As the work progressed, the wye connections to the C. J. Ry. were abandoned temporarily, and traffic between the two companies handled by another route.

The material used for filling was sand similar to that used in other elevation work in Chicago. It was obtained about 22 miles out on the line of the P., F. W. & C. It was loaded into ordinary gondola cars by steam shovel and unloaded entirely by hand.

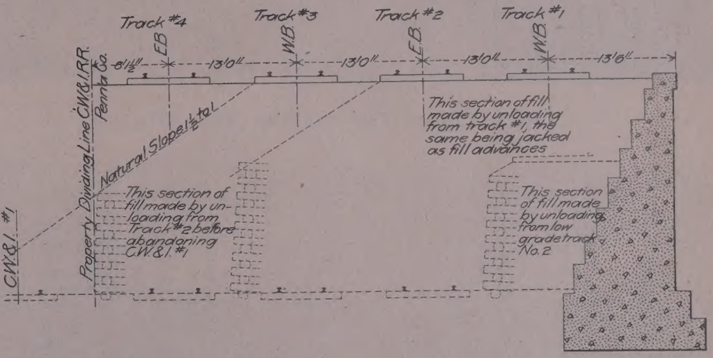
Nearly all concrete was machine mixed, paddle machines being used for this work.

In accordance with plan adopted for carrying on the work, no effort was made to build abutments (except foundations) or piers, until after all tracks were raised, and temporary trestles were, therefore, constructed at each street crossing, piles being driven to a depth of 6 to 8 ft. below the bottom of the proposed excavation for the pier and abutment foundations.

At crossings where street railway tracks were in service, steel I-beams were used for spanning the tracks, thus avoiding the necessity for spreading them to clear a pile bent placed between them.

On account of narrow working space, it was necessary to use cribbing for retaining the sand slopes, and for this purpose a crib-work of old ties was constructed. With such a crib-work, considerable sand drifted through, particularly on windy days, but the expense of keeping it cleared away from the track next to the crib was very slight. The general character of this cribwork is shown in one of the illustrations.

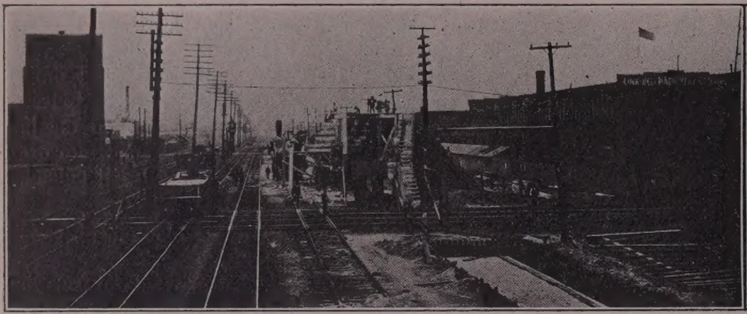
Cribwork for Retaining Sand Slopes.


Track #4
E.B.
Track #3
W.B.
Track #2
E.B.
Track #1
W.B.
8'1½"
13'0"
13'0"
13'0"
13'6"
Property Dividing Line C.W.&I.R.R. Penna. Co.
Natural Slope 1½ to 1
C.W.&I. #1
This section of fill made by unloading from Track #2 before abandoning C.W.&I. #1
This section of fill made by unloading from track #1, the same being jacked as fill advances
This section of fill made by unloading from low grade track No. 2

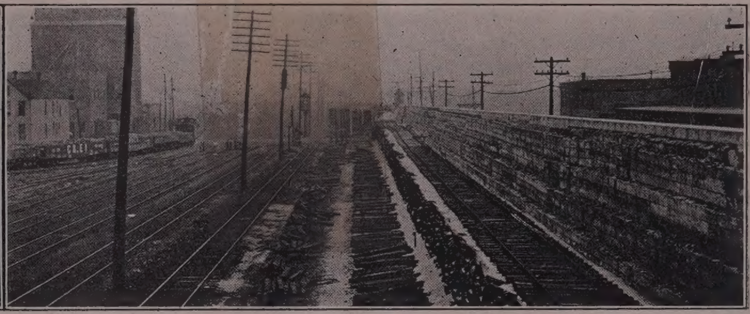
Cross-Section of Old and New Locations.

As soon as tracks were abandoned for traffic, piles were driven for half-weight trestles on track No. 1 at all street crossings. Trestles were then framed up, except in the center, where two spans were left open for street traffic. Following the pile driver, track No. 1 was torn up and removed, cribwork was built, sand was unloaded from track No. 2 to build the bank to half-height, or as high as could be built by shoveling from a gondola car, and track No. 1 was then relaid on this bank. After completing the trestles on track No. 1, those for tracks Nos. 2 and 3 were built to full height, and these tracks were torn up and removed. Sand was next unloaded from track No. 1, at its new elevation, and this track was jacked to the full elevation, the bridges being raised on extra caps as the track-raising progressed. This work was done, however, in short stretches to avoid closing more than one or two streets at a time, and the work north and south of 40th St. was carried on independently as this crossing could not be blocked by a low-grade bridge.

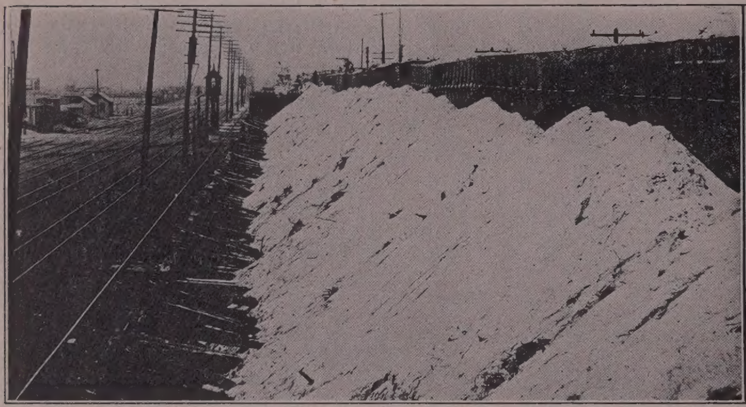
Having raised track No. 1 to full height throughout, trestle was constructed across 40th St., and using this track for unloading, the bank was widened for additional tracks, traffic being transferred from the low track to the high track one at a time, as the work progressed. The accompanying illustrations show these various steps as carried out and also the various steps in the grading. The various steps followed out at the street crossings are shown by the photographs taken at Root St.



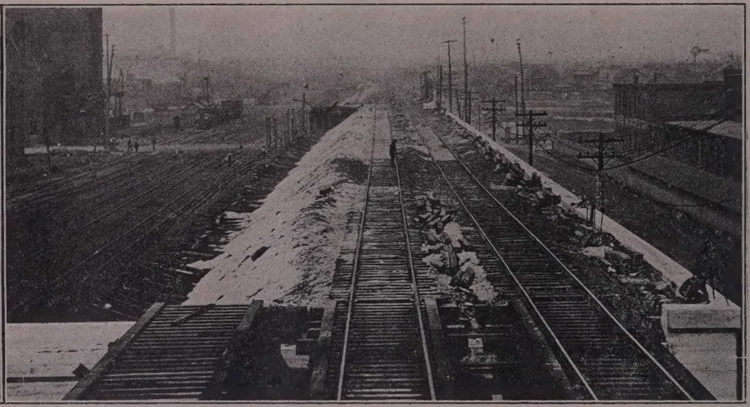
View of Early Work on Tracks.



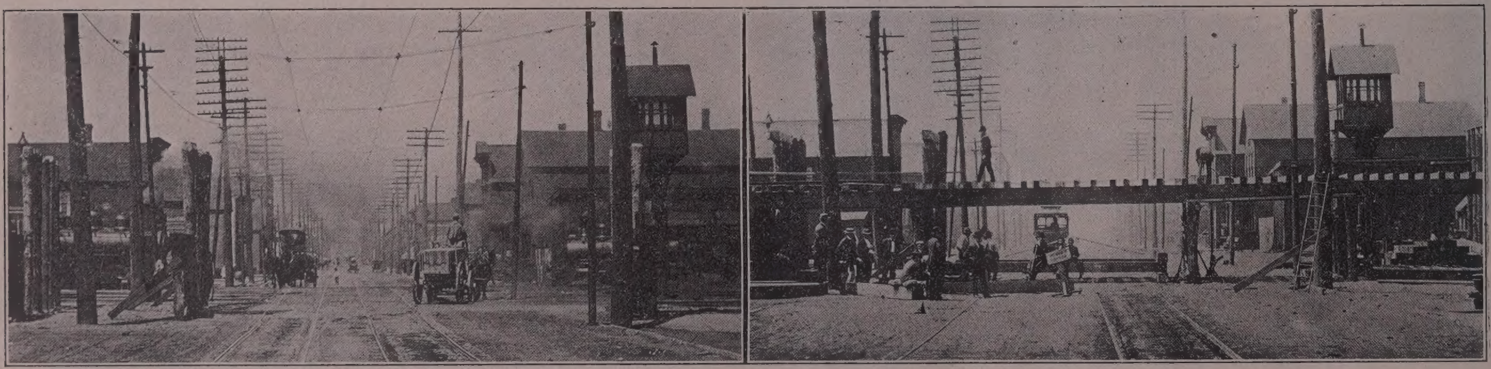
No. 1 Track Relaid at Half Height, June 29.



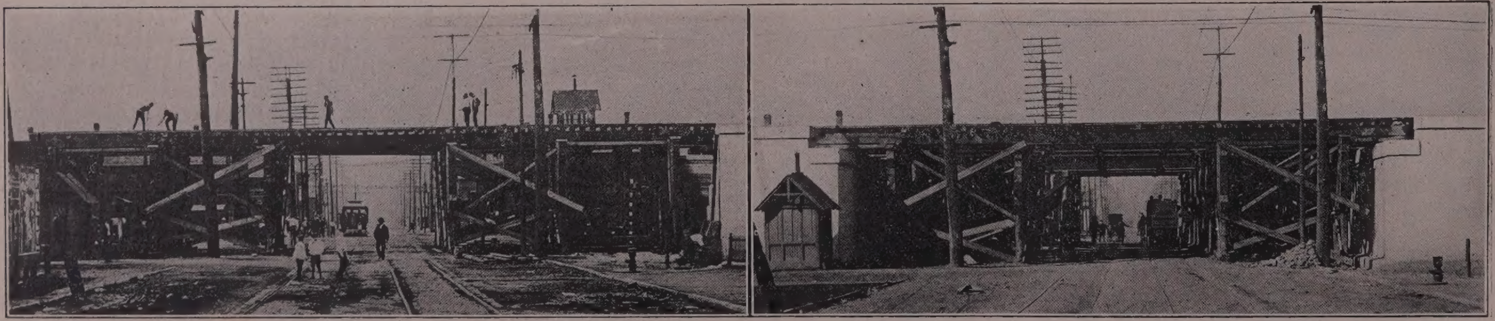
No. 1 Track Full Height, July 20.



Nos. 2 and 3 Tracks at Full Height, Aug. 30.



Views at Root St. Crossing Showing Condition of Overhead Tracks on July 5 and 27.



Root St. Crossing on Aug. 5, with No. 1 Track at Full Height, and on Sept. 28 with Finished Abutments.

All plans for the work were prepared in the office of the chief engineer of maintenance-of-way of the Northwest System, Mr. R. Trimble, under general supervision of the chief engineer, Mr. Thomas Rodd. The work of construction was in the immediate charge of Mr. D. M. Craig, assistant engineer, from the office of the chief engineer of maintenance-of-way.

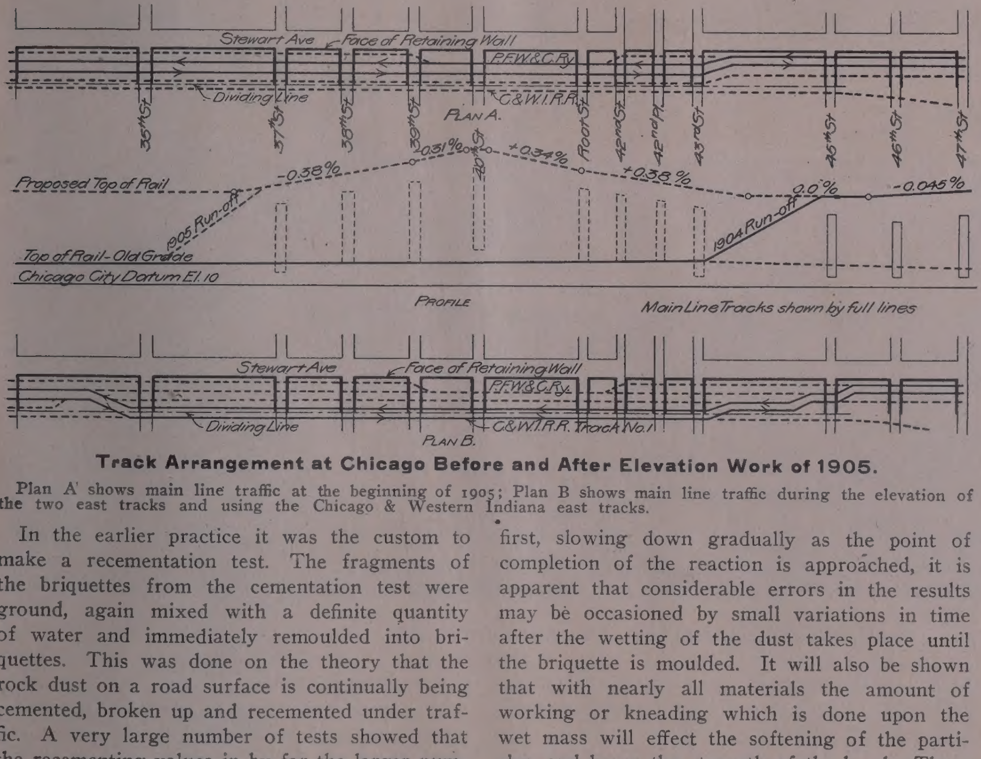
THE HIGHEST DAM in Europe is stated to be that of the Urft valley power development in Austria. It is 190 ft. high, 741 ft. long and 166 ft. wide. The reservoir furnishes water to a power station which is equipped with 2,000-h.-p. turbines.

The Development of the Test for the Cementing Value of Road Material.

A paper read before the American Society for Testing Materials by Allerton S. Cushman, Assistant Director, Office of Public Roads.

The old idea that any stone was good enough to build a road of has been replaced by the knowledge that rocks, even of the same type, vary within wide limits in their physical properties, some of them being quite unsuited for road building. It is evident that in order to keep a road surface compact and in good order, not only must dust be continually worn off to take the place of that removed by various agencies, but also the dust which has formed must be capable of forming a bond between the larger stones which make up the aggregate.

The first attempt to develop a test for cementing value was made by L. W. Page in 1893, working in cooperation with the Massachusetts Highway Commission. In the earlier attempts, the fine dust which was worn off in the abrasion test and which had passed a 100-mesh sieve was tempered with water and test pieces of varying sizes and shapes were moulded. It was found that neither compression nor tension tests gave satisfactory results, and the method finally adopted consisted in moulding test pieces in a cylindrical die under a definite pressure. The test pieces which were finally adopted were 25 mm. in diameter and 25 mm. high. These little cylindrical briquettes, after being thoroughly and carefully dried, were broken under the impact of a 1-kg. hammer falling 1 cm., the blow being repeated until failure occurred. The details of the method and the machine used have been published in several places and need not be repeated here. In later work the practice of using the dust from the abrasion test was discontinued and a definite quantity of the stone was ground to a fine powder in a heavy iron ball mill. The fine dust resulting from this grinding was passed through a 100-mesh sieve and the test pieces moulded as described, a hydraulic press being used to apply a definite load at a definite rate.



Track Arrangement at Chicago Before and After Elevation Work of 1905.

Plan A shows main line traffic at the beginning of 1905; Plan B shows main line traffic during the elevation of the two east tracks and using the Chicago & Western Indiana east tracks.

In the earlier practice it was the custom to make a recementation test. The fragments of the briquettes from the cementation test were ground, again mixed with a definite quantity of water and immediately remoulded into briquettes. This was done on the theory that the rock dust on a road surface is continually being cemented, broken up and recemented under traffic. A very large number of tests showed that the recementing values in by far the larger number of cases were smaller than the corresponding cementing values. There were, however, a number of cases in which the reverse took place. This is shown in Table 1, in which the cementing and recementing values of a number of rock species are compared:

TABLE 1.—COMPARISON OF CEMENTING AND RECEMENTING VALUES.

Name.	Cementing Value.	Recementing Value.
Diabase (trap)	110	89
Ferruginous limestone	158	72
Dolomitic limestone	59	42
Novaculite (chert)	24	18
Limestone	95	29
Dolomite	32	23
Sandstone	54	23
Diabase (trap)	49	44
Limestone	8	13
Gravel	11	13
Limestone	22	34
Limestone	110	126
Dolomitic limestone	22	30
Hornblende schist	7	9

These anomalous results called for a thorough investigation of the whole question. As it is well known in clay working that the soaking and kneading of a clay for protracted periods increases not only the plasticity, but the binding power, it was suspected that the prolonged action of water on fine rock dust might well increase the binding power at least up to some maximum value. Investigations were at once begun to see if the underlying cause of the cementing power could be discovered. It is sufficient to say here that the conclusion was reached that the rock powders which have binding power invariably undergo decomposition under the action of water, the decomposition products forming soft, more or less adherent films on the surface of the particles. On drying out, this adherent bond locks the particles together. In the case of clays this bond is usually very strong, while with rock dust it is extremely variable, ranging from those which yield briquettes that break on the first blow to those which will sustain hundreds without failure.

After the observation had been made which led to the conclusion outlined above, it became evident that a modification was necessary in the manner of making the briquettes for the cementation test. Since the bond is developed under the prolonged action of water, it is manifestly unfair to wet the rock dust and immediately mould the test pieces. Moreover, as the action of water begins at once, and according to the laws of physical chemistry, it is more rapid at first, slowing down gradually as the point of completion of the reaction is approached, it is apparent that considerable errors in the results may be occasioned by small variations in time after the wetting of the dust takes place until the briquette is moulded. It will also be shown that with nearly all materials the amount of working or kneading which is done upon the wet mass will effect the softening of the particles, and hence the strength of the bond. These variations were sufficiently large in some cases to account for the anomalous results in the cementation and recementation tests; hence the recementation tests were immediately given up as being of no value, and methods were devised by which the cementation test was improved.

The finely ground and sifted rock dusts were mixed with a sufficient quantity of water, and were worked and kneaded until an even consistency of stiff dough was obtained. From these doughs series of briquettes were made at intervals and tested. There is invariably a rapid rise in binding power in the newly made doughs, and after the lapse of twenty-four hours the value has, for the purpose of the test, become practically constant. This effect is, of course, more apparent in materials of high cementing value than in lower ones. Numerous experiments have shown that with powders, such as fine sand, which have no particles of a colloidal nature and therefore no binding power, soaking or kneading will not develop the slightest increase. In carrying out the cementation test the doughs were invariably aged for at least twenty-four hours, and the workman was trained to knead the dough always in the same manner for about the same length of time. Careful attention to these details resulted in a great improvement in the value of the test, both in a lessening percentage of variation in different test pieces of the same series, and also in the agreement of the tests with the results of service.

Rocks are far from being homogeneous materials, and in addition the cementing power itself is such a variable quantity that it may be said that the test has served its purpose if it does no more than distinguish high binding material from that which is only fair, and this in turn from that which has little or no binding power.

Further experiments which were undertaken a little later showed that the binding power is still more increased if the dough or paste of rock dust is kneaded or worked by hand. This is plainly shown by the results obtained on a sample of dolomite which is celebrated as a binding material in the locality in which it occurs. The most marked characteristic of this rock is the way that its binding power increases after it has been on the road for some time. The results shown in Table 2 were obtained by mixing the sifted dust with water and moulding briquettes of the paste at separate intervals; finally a new lot of the dust was made into a paste and well kneaded by hand for one hour.

TABLE 2.—EFFECT OF AGE OF ROCK DUST PASTE.

Time.	Cementing value.
At once	16
Dough 4 hours old	50
" 24 " "	81
" 72 " "	79
" 96 " "	77
" 120 " "	79
" 144 " "	83
" 8 days "	81
" kneaded 1 hour	190

It now became apparent that a system of wet grinding would develop much higher values than could be obtained by grinding the sample dry and subsequently mixing with a given amount of water. In order to investigate this point a series of experiments was made in which kilogram charges of rock dust were ground with approximately 20 per cent. by weight of water in a ball mill for three hours. Without exception the binding power has been increased by this method of procedure, as is shown in Table 3.

TABLE 3.—RELATIVE CEMENTING VALUE OF VARIOUS ROCK SAMPLES WHEN GROUND WET AND DRY.

Kind of rock.	Dry grinding.	Wet grinding.	Increase.
Chert	6	23	17
Dolomite	28	31	3
Diabase	15	121	106
Sandstone	25	78	53
Limestone	9	28	19
Basalt	128	500	372
"	12	125	103
"	15	25	10
"	21	421	400
Sandstone	61	174	113
Gneissoid granite	1	35	34
Dolomite	32	174	142
Slate	14	43	29
Gneiss	2	52	50
Dolomite	13	43	30
Chert	1	22	21
Hornblende granite	1	29	28
Granite	1	53	52
Chert	12	106	94
Dolomite	5	48	43
Dolomitic limestone	2	18	16
Syenite	5	20	15
Dolomitic limestone	6	55	49
Limestone	17	55	38

It has been shown in previous publications that the binding power of rock dust depends upon the decomposition of the mineral constituents of the rock under the action of water. The decomposition products which are formed principally as films on the surface of the particles may not invariably cause a strong bond of cementation, as they are not all alike in this respect, but wherever a bond is formed it is certain that more or less decomposition has taken place. In view of this it is quite apparent that the effect produced by kneading and wet-grinding is due to the increased action of the water. Under the action of iron-shod traffic a road surface is frequently being acted on by a species of wet-grinding, and it is precisely for the reason that automobile traffic has no such action that a new problem has arisen in highway maintenance. The action of water under the roller in aiding the formation of the original bond is well known to engineers, and in macadam construction the roadway is generally liberally sprinkled while the final consolidation is going on. It would appear from what has been said that in the case of most rocks the more wet rolling they are subjected to the better the result.

Lately porcelain pebble mills have been substituted for the heavy, cumbersome iron ball mills, in carrying out the cementation test. At first some difficulty was experienced in grinding up the material with water to the maximum cementing values obtained in the iron mills. As now carried out the rock dust which has been ground dry in a disk grinder to about 8 to 40 mesh size is transferred to a porcelain pebble mill with sufficient water to make a slip rather than a paste. The mills are about 8x10 in. internal dimensions and are capable of grinding about 1.2 kg. of material. Four kilograms of flint pebbles are used, in assorted sizes ranging from about the size of a bantam's egg to that of a boy's playing marble. The mills are revolved at the rate of 50 r.p.m. for four hours. At the end of this time the slip or slime is transferred to a pan and quickly dried to the consistency of a paste suitable for the molding of briquettes. The great ease with which a large battery of these small mills can be worked at the same time makes it possible to carry on both the routine tests and investigation work with much greater facility.

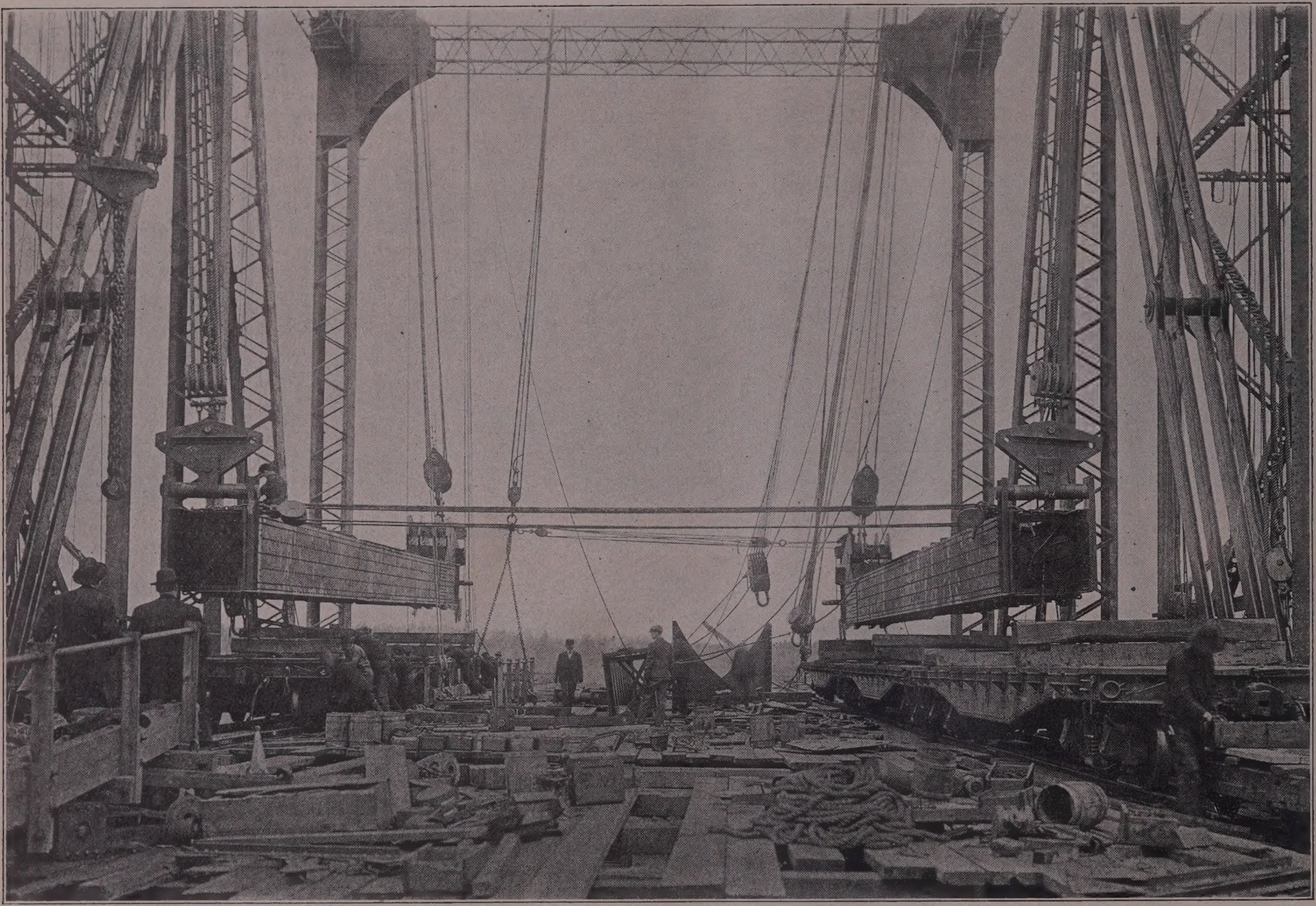
The latest experiments which have been made have developed a field of investigation which promises to be of great interest, both on the theoretical and practical sides. It appears that the addition of lime or limestone will greatly increase the cementing value of an acidic rock like granite.

The results that are shown in Table 4 were obtained by mixing together equal quantities of limestone and granite rock powders of known cementing value and grinding the mixture with water.

Table 4.—Cement Values of Mixed Rock Dusts.

Limestone.	Granite.	Combination.
20	6	82
26	7	53
22	9	56
13	10	22
27	3	110
26	7	38

It is well known to agricultural chemists that the addition of lime and land plaster to a soil hastens the decomposition of the natural silicates, thus setting the mineral plant foods free. It would now further appear that the scientific road builder should seek to blend his material whenever such a thing is possible, so as to bring about the greatest amount of decomposition possible among the rock particles on which he depends for the formation the bonded surface of his road.



Lifting Upper Sections of Vertical Post P4, April 26, 1906.

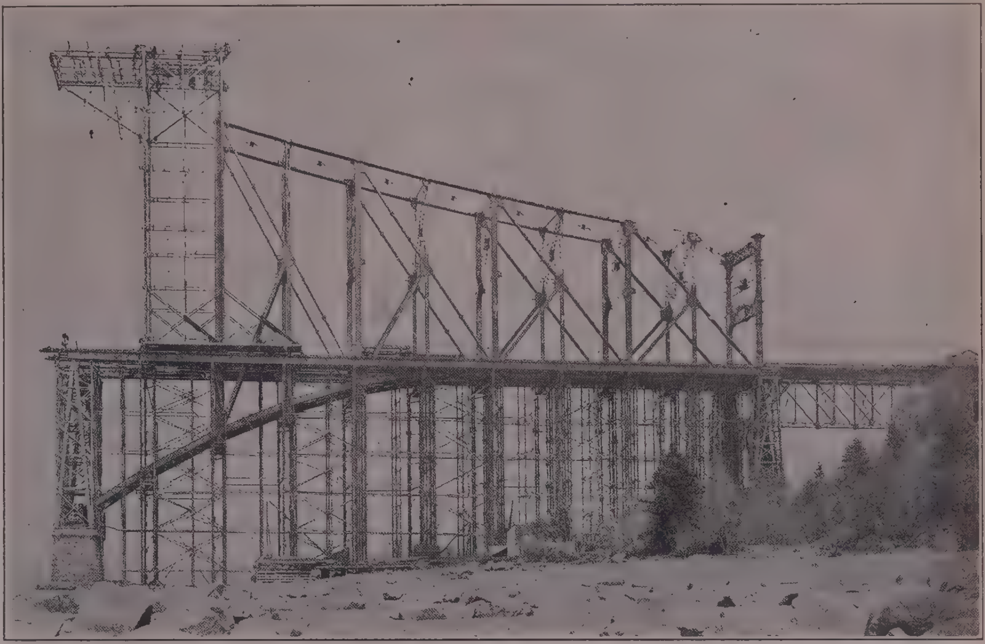
The Progress of the Quebec Bridge.

The fourth principal step toward the construction of the 1,800-ft. span, $4,000,000 bridge across the St. Lawrence River at Quebec has just been completed. These steps included, first, the construction of the substructure for the whole bridge, consisting of four pneumatic caisson piers, at a cost of about $1,000,000; second, the erection of the 1,200 tons of steel falsework, the 500 lin. ft. of wooden falsework for material tracks and the steel traveler, together with the installation of the $250,000 erection plant; third, the fabrication at Phoenixville, Pa., of the 14,000,000-lb. anchor arm span; fourth, the erection of the anchor arm span which was commenced last summer and was practically completed last week.

The succeeding steps in the construction of this bridge will be, fifth, the erection of the south cantilever arm, which it is hoped will be completed this summer; sixth, the erection of the falsework for the north anchor arm; seventh, the erection of the permanent steelwork of the north anchor arm; eighth, the erection of the steelwork of the north cantilever arm, and, ninth, the erection of the suspended span. The fabrication of the remainder of the steelwork at the Phoenixville shops might be classified in four more steps, but as it will be accomplished simultaneously with some other parts of the work and will not be rigidly separated in the shops, it may be considered as an extension of the work mentioned in the third step.

Now that the work has progressed so far, it becomes still more impressive, and as the very successful features of the structural design and of its novel details and those in the methods of the plant adopted for its erection are noted, it emphasizes conviction of the important place of this structure in the history of bridge building. The operations of manufacture and erection, although very thoroughly planned and carefully detailed as described in The Engineering Record of March 4, 1905, were then to some extent theoretical since many of them were entirely new developments created for this structure and transcending in magnitude those of any existing structure. No precedent existed, and as many new features had been adopted, the degree of success of the great undertaking still remained to be actually demonstrated. Since that time the completion of the anchor arm, one of the five great elements of the structure, has been successfully accomplished; most of the new features of design and erection have been tested; the great erection plant has been completed and operated most satisfactorily and the success of the work up to this point gives assurance of its continuation through the completion of the monumental structure.

As described on March 4, April 1 and April 8, 1905, the bridge has a total length of 2,800 ft. on centers of anchorage piers, and crosses the rocky bed of one of the greatest rivers in the world where the water has a maximum depth of 200 ft. and a swift current, often obstructed by enormous fields of heavy ice which preclude the possibility of any direct support for the superstructure in the center of the main channel. Work on the substructure was commenced in 1900, and the contract for the superstructure was finally awarded in 1904, with the requirement that it be completed in 1908, a schedule which the chief engineer expects to follow.



South Anchor Arm, Traveler and Steel and Wooden Falsework, May 7, 1906.

Lifting Complete Assembled Panels of Top Chord, Nov. 17, 1905.

The superstructure has two pin-connected steel trusses continuous for the full length of 2,800 ft., which are symmetrical about the center line and include two 500-ft. anchor arms, two 562½-ft. cantilever arms and one 675-ft. center suspended span. The latter is much longer than any simple pin-connected truss span yet built, and the total length of the channel span, 1,800 ft. between centers of piers, exceeds by 90 ft. the span of the Forth bridge, so long the greatest in the world, but which has a much smaller capacity and much greater relative weight than that of the Quebec bridge.

The channel span has a clear center height of 150 ft. above high water, and the trusses have a maximum depth of 315 ft. on centers of main vertical posts. The steelwork, however, extends 41 ft. higher, so that the highest point is over 414 ft. above low-water level. The trusses are made with parabolic top and bottom chords giving a very graceful outline to the elevation of the bridge. They are in vertical planes 67 ft. apart, carrying at a height of about 120 ft. above the substructure and about 178 ft. above low-water level a single roadway platform supporting between them two railroad tracks, two highways, and two electric car tracks, with provisions for two sidewalks outside of the trusses. These loads, together with a wind load of 25 lb. per square foot and a provision for 50 per cent. increase in the heavy train loads, are combined with the dead loads resulting from about 80,000,000 lb. of steelwork, which is so proportioned that the maximum unit tension stresses do not exceed 17,000 lb. per square inch in the I-beams or 20,000 lb. per square inch in any of the secondary members.

In designing the superstructure special pains were taken to conform to the most advanced shop practice and make the details of the members such that they could be most accurately and advantageously built, and safely and rapidly erected. The dimensions were in many cases determined by the possibility of transportation, and the reasonable limitations of modern materials and machinery for handling them in the field. Great care was taken in the determination of governing features of the members, and they were finally settled after conference with the railroads and investigation of the feasibility of securing the unusual materials required for some of them. In several cases the materials used were about the present limit of production of the steel mills and of the capacity of the tools by which they were worked in the shops. It is a source of justifiable pride to the contractors that all of the intricate and important detail drawings have been made by their own regular engineer corps under the direction of Mr. P. L. Szlapka, designing engineer, and Mr. A. B. Milliken, superintendent of erection. These drawings involve some of the most elaborate ever required for such work, some of the single sheets being 12 ft. in length and costing over $1,000 each.

The trusses in the south anchor arm are duplicates of those in the north anchor arm and, as before stated, have a length of 500 ft. center to center of end pins. They are 96 ft. 9⅜ in. deep over the anchor pier and 315 ft. deep over the main pier, and are divided by vertical posts into ten panels of approximately 50 ft. each. The main diagonal members each cross two of these panels, intersecting the vertical post at the center point, where the tension members are connected to it with separate pins on opposite sides of the post. The compression diagonals have riveted connections, but the vertical posts and top and bottom chords have pin-connections, most of them using pins 12 in. in diameter, although some of them have twice that diameter.

A peculiarity of the design consists in the connections of the diagonal eye-bars to separate pins through heavy gusset plates riveted to the vertical posts, thus reducing the number of members assembled on the chord pins and facilitating the work of erection. The lateral and sway-brace systems are themselves series of important trusses, all with riveted connections and having many long and massive members. The two main vertical posts, together with their transverse bracing form a huge truss 315 ft. high and 67 ft. wide, which weighs 3,000,000 lb.

All of the vertical posts in the anchor arm span are made in two or more sections each, except the shortest ones at the shore end. The chord pieces are all in single-panel sections which, on account of the inclination from the horizontal, have lengths of about 60 ft. The bottom chord, about 4½ ft. deep and 5½ ft. wide, are made with four webs and have a maximum cross-section of 842 sq. in., the heaviest piece weighing about 100 tons. The 15x2⅛-in. eye-bars have a maximum length of 76 ft., the 12-in. pins are some of them more than 10 ft. long, 24-in. pins 7 ft. long, the main shoes weigh 46 tons and the 10½x60-ft. floorbeams weigh 30 tons each.

The maximum top-chord sections in these trusses have a maximum stress of 14,245,000 lb. plus a wind stress of 1,610,000 lb. for which there is required a cross-sectional area of 711 sq. in. Vertical post P4 at the second panel point from the main pier has 275 sq in. cross-section, is 224 ft. long on centers, and is shop riveted in three lengths.

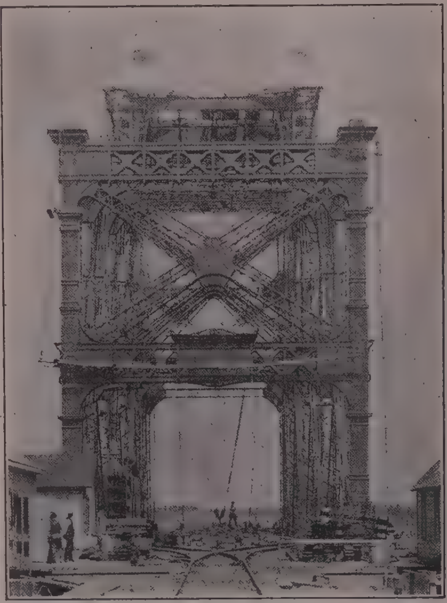
These members are transported by rail from the shops to the bridge site and many of them are loaded on two or three standard steel cars; for others special steel cars have been built expressly. The steelwork has been manufactured in the shops, which have a capacity of 100,000 tons a year, with the use of very little special plant and without interrupting the execution of other contracts, at the rate of about 3,000 tons per month. The different invoices are from 10 to 14 days in transit between the shops and the site, and care has, of course, been taken to send the material in the order required for erection. At present about 3,000 tons of the superstructure has been shipped to the site, including nearly all of the material for the south cantilever arm. The members of the north anchor arm and most of the north cantilever arm have been manufactured and are now stored at the shops.

The anchor span was erected on eighteen 9x9-ft. steel falsework towers from about 127 to 160 ft. high, braced together in pairs to form transverse bents at the panel points. The members corresponded to railroad viaduct work and were field-connected with turned bolts allowing them to be easily disconnected for removal and re-erection on the opposite side of the river. Materials were delivered for the erection by two standard gauge tracks run close to the trusses and supported on independent wooden falsework about 166 ft. high with five or six-story bents each made with five vertical posts braced together to form towers located between those of the steel falsework.

The bridge members were unloaded, stored in a large yard at the bridge site, and reloaded on delivery cars by a pair of 60-ton gantry cranes with 68-ft. spans and a clearance of 30 ft. above the ground. These cranes traveled on a 750-ft. runway and like all of the hoisting engines, air compressors, and other machinery in the plant are operated by electricity. The bridge members were erected and assembled by a 54x103-ft. steel traveler 212 ft. high, with 54-ft. and 66-ft. rear and forward, bottom and top cantilever extensions, giving a Z-shaped outline in side elevation. This traveler runs at roadway level, astride of the finished truss which it clears, enabling all of the transverse bracing to be completed as the trusses are assembled. It is designed with sufficient stability to handle its loads and endure the violent wind stress without guying, but it is, of course, anchored to the stringers when in service. It is equipped with thirty-three tackles of 12 to 55 tons capacity which are operated by four 2-drum, 4-spool electric hoisting engines of special design, made by the Lidgerwood Manufacturing Co. The total weight of the traveler with its engines and rigging is about 2¼ million pounds.

After the bottom chords of the anchor span were assembled by the main traveler on special camber blocks on the steel falsework, the erection of the anchor-arm truss was commenced at the anchor pier and has been continued, panel by panel, to the main pier without interruption except from November, 1905, until April 17, 1906, when operations were stopped for the winter. The largest pieces handled so far in the erection have been the center sections of the main vertical posts, which weighed about 95 tons each. These pieces have a 5x10-ft. cross-section with four transverse webs and a sectional area of 553 sq. in., designed for a maximum working load of about 10,000,000 lb.

The picture dated May 7, 1906, is a general view of the south anchor arm and shows the approach span complete and all of the anchor arm steel work, except the two panels nearest the river. The steel traveler is seen ready to commence erecting the last panel, the bottom chord of the anchor arm is assembled on the falsework, showing the curved outline, and all of the steel and wooden falsework is in position although a portion of the wooden falsework has been removed since transfering the material tracks to the permanent floor platform. The steel falsework will remain in position and will be necessary to support the superstructure until several panels of the cantilever arm have been built, reversing the stresses in the anchor arm trusses and releasing the falsework.



South Portal, May 19, 1906.

The picture dated April 26, 1906, is a view looking north across the river along the axis of the bridge and shows the method of erecting the riveted truss members in pairs. The upper sections of vertical posts P4 have just been hoisted simultaneously from the steel cars on the material tracks close to the trusses. Special yokes are bolted to each end of the posts and are designed to suspend the latter eccentric from their axes so that they may be held through these lateral connections in a vertical or inclined position. They are provided with horizontal connection pins forming pivots above which the member is free to adjust itself to the lengths of the tackles and the required positions. These pivots are connected with the tackles by intermediate links made of solid plates and arranged for the attachment of one, two or three tackles; in this case only one tackle is required for each post. The tackles are suspended from the traveler just inside the planes of the trusses and are connected at the lower ends by light horizontal hand tackles transverse to the axis of the bridge, so as to pull them into an inclined position and enable the posts to be raised clear of the trusses. At the required elevation these tackles are slacked off allowing the posts to swing back into the planes of the trusses where they are assembled and the final connections are made. Both vertical and inclined posts are delivered on steel cars which are removed as soon as released. After this, the tackles are operated so as to swing the posts to the required vertical or inclined positions and then hoist them to place. This method distributes the load between the two tackles in a varying and uncertain proportion, so that although the tackles assist each other one of them is sure to receive more than one-half of the load. With this arrangement the posts are hoisted and connected almost as rapidly as much smaller members are erected by ordinary methods. The work is also done more easily than ordinary bridge erection, because all of the apparatus is so heavy that it cannot be lifted by hand and electric power is used to handle it. The workmen are thus relieved of nearly all labor except to adjust and connect the apparatus during the operations.

The picture dated Nov. 17, 1905, shows the method of hoisting the top-chord bars by a device similar to that used for the vertical posts and other riveted members. A single top chord panel has twenty-eight 15x2 1/16-in. eye-bars weighing together 140 tons. These must be matched and assembled with corresponding bars in the adjacent panels and with the webs of the vertical and inclined posts, thus making connections in which they receive as many as sixty bearings of a 12-in. pin 10 ft. long. It is evidently an exceedingly difficult operation to adjust all of these heavy members, some of them inflexible and all very rigid, at the great height of the top chord, a maximum of over 370 ft. above low water level. To simplify this a method has been first adopted on this bridge of assembling the bars for one panel of the top chord complete in the storage yard, where they are spaced to the exact position by wooden fillers and firmly clamped with steel bolts and yokes, so as to be in exact alignment and receive their pins. They are then delivered on two or three cars on material tracks under the traveler and both corresponding panels of the two trusses are hoisted to position simultaneously by two pairs of tackles for each, in much the same manner as described for the riveted members. A modified form of yoke is used for connecting the tackles to the bars, and in this case it is seen that it is used at one end with double tackles and at the other end of the eye-bars with single tackles. This arrangement readily permits the inclination of the bars to be adjusted to any angle. In practice it has been found that a complete set of eye-bars could be hoisted and connected more quickly than two or three single flexible bars can be added to the incomplete panel.

Mr. E. A. Hoare is the chief engineer and Mr. Theodore Cooper, consulting engineer, of the Quebec Bridge Co. The contractor for the steelwork and erection is the Phoenix Bridge Co., Mr. David Reeves, president and Mr. John Sterling Deans, chief engineer.

The Structural, Municipal and Sanitary Aspects of the Central Californian Catastrophe--IV.

By Charles Gilman Hyde, Assoc. M. Am. Soc. C. E.

The Water Supply Problem.—The effect of the earthquake upon the systems of water supply within the region under consideration is one of utmost significance and of far-reaching importance. With the passage of time the engineer, like other human beings, is somewhat inclined to forget the lessons which are plainly taught by great natural disturbances such as earthquakes, floods, great and extended droughts, tidal waves, etc. In the present case there have been produced very marked results capable of certain interpretations which should affect all future design and construction of water supply systems in this territory. The experience to be gained from a study of the disastrous effects now before us may be made very valuable in the future. The solution of all of the problems which are involved is not, perhaps, at this moment perfectly clear; it can only be made manifest after the data have been collected and after a careful investigation has been made of all the prevailing conditions.

Opening of Joint on Pilarcitos Pipe Line.

Destruction of Sewer by Settlement of Street.

In the first of these views, the joint, which has been pulled open 53½ in., was made with a wrought-iron collar, leaded and calked. A fence at this place, where the line of the fault coincided with the line of the pipe, was ruptured and the two ends separated 7 ft. In the second picture, taken on Valencia St., between Eighteenth and Nineteenth Sts., the broken sewer is in a deep fill along the former course of Mission Creek.

The effects of the earthquake upon water works structures in this region may, perhaps, for the purposes of the present discussion, be best classed as follows:

(a) Those produced directly along the fault by disrupting and vibratory forces of great magnitude.

(b) Those resulting elsewhere due to vibration and consequent distortion, especially of aerial structures, such as pipe lines supported by trestles.

(c) Those produced by the oscillation of the ground and the settlement of the material at or near the surface.

So far as the writer has been able to learn no serious injury due to the earthquake was sustained by any important earth or masonry dam within the region of San Francisco Bay. This fact is the more remarkable since one of these dams—to-day become one of the most important —was situated directly across the line of the fault previously described. The dam in question is the San Andreas, creating the reservoir of the same name, a part of the system of the Spring Valley Water Co., formerly supplying the middle-level district of San Francisco.

SAN ANDREAS DAM.—The San Andreas dam is well known to engineers and has been abundantly described in engineering literature. The main structure, of earth, is about 95 ft. high, at the deepest part of the valley across which it is thrown. It was constructed about 1868. Excavation for the dam was carried down into the solid rock along a trench about 5 ft. wide and 2 ft. deep in which a concrete cut-off wall was placed. The top of this wall was brought up to a point somewhat above the stratum of hard pan or disintegrated rock upon which the lower portion of the core of puddled clay, 20 ft. in width, was constructed. The upper surface of this specially prepared puddle was brought to a point well above the surface of the valley. From this point the core wall of selected clayey materials and the earth embankments were constructed together, the layers of material being placed from the upper and lower faces alternately to the further side of the core wall at slopes inward, toward the center, of about 1 in 20. These layers were never more than 12 in. thick and were thoroughly compacted with heavy rollers.

By some unhappy coincidence the plane of the fault passed through this region at the extreme easterly end of the main dam, at the junction with an original promontory of firm material. On the other side of this peninsula, so to speak, still further eastward, a smaller auxiliary dam or dyke was constructed. Without any question these embankments were subjected to very considerable oscillations and vibrations whose only effect was to produce visible longitudinal cracks on the surface of the roadway along the top at either edge of the core wall of puddle. These cracks could be interpreted to indicate some slight relative displacement, probably a settlement only of the materials comprising both the upper and lower parts of the dam on each side of the puddle core. Some severe cracks, transverse to the line of the dam, were to be observed in the originally undisturbed and firm material of the promontory above mentioned. Through the kindness of Mr. Herman Schussler, chief engineer of the Spring Valley Water Co., who found time at this busy period to extend many courtesies of this nature, the writer was enabled to make a thorough examination of this structure, particularly along the outer toe where no evidence of any leakage whatever was to be observed. Moreover, although the fault passed through this reservoir for a considerable distance, no loss in storage, beyond that attributable to evaporation and to draft due to consumption, has been noted by the engineers of the Spring Valley Co.

OTHER DAMS.—Two other important dams of the Spring Valley system in this vicinity were somewhat removed from the fault line. One of them is the well known earth dam, 95 ft. high, forming the Pilarcitos reservoir, constructed to supply the high service district of San Francisco. This dam is located about 1.8 miles west of the line of the fault and was absolutely undisturbed by the earthquake. The other dam is the very heavy high concrete structure known as the Crystal Springs, or San Mateo dam, curved in plan, removed less than 1,000 ft. from the fault which, opposite this point, passed within the Crystal Springs reservoir. Judging from the nature of the earthquake action, this dam must have been subjected to an immense thrust in the direction of its length and also to some transverse vibrations. An examination of the structure shows it to have been entirely uninjured. The records of gauge height indicate no loss in storage in this chain of reservoirs consequent upon the fault line produced within their bottoms.

Another very important and well known dam in the region affected by the earthquake is that of the Contra Costa Water Co., at San Leandro, on the east side of San Francisco Bay, about 10 miles southeast of Oakland. This is 125 ft. high and is said to be the highest earth dam in the United States. So far as superficial examinations can show this dam sustained not the slightest injury from the earthquake.

Smaller dams belonging to various water companies in the region about San Francisco Bay, have not been harmed, nor does it appear that distributing reservoirs in earth have been injuriously affected by the earthquake. The writer has had under observation, with peculiar interest, one of these reservoirs constructed partly in excavation and partly in fill, the embankments being very high and quite steep. The reservoir in question is the property of the Contra Costa Water Co., and is located in North Berkeley at the end of Euclid Ave. The depth in this reservoir at high water mark must be at least 50 ft. During its early history this reservoir is said to have leaked seriously, so badly in fact that its use was for a time abandoned. Unsuccessful attempts to waterproof it were made, but at length by the use of an asphalt lining satisfactory results were obtained. The reservoir appears to have received no injury whatever from the earthquake and on May 6 it was almost completely full of water.

The Pilarcitos Pipe. The only pipe line whose location coincided with the plane of the fault for any considerable distance, if at all, is that known as the Pilarcitos, supplying from the reservoirs of that name, a part of the high-service district of San Francisco. By some freak of nature, this splendidly designed and constructed pipe was laid for about 3½ miles along a course which the plane of rupture causing or caused by the earthquake chose to follow. The result was the absolute destruction of this important line throughout practically the entire distance just stated. The writer traversed this length and found 17 places where the joints had been torn asunder or where a telescoping action had taken place, or where a combination of these effects was produced. In this connection it should be stated that the points of injury which were observable were probably only the more important ones. Many less prominent breaks were not to be ascertained without completely uncovering the pipe. In general only the larger breaks, where the pressure was sufficient to cause a "flow-out" at the surface of the ground, were made manifest. There were some important exceptions to this rule, however.

From almost every engineering standpoint this pipe appears to have been well designed and well placed. The pipe is of riveted wrought iron specially rolled to produce a tough, reliable and non-corrodable material. The metal appears to be generally about 3/16 in. thick with transverse joints having one row of ⅜ in. rivets with 1 3/16 in. pitch. So well designed was this pipe that of the many cases of transverse rupture examined by the writer about one-half of the joints were found to have failed by the tearing of the metal between the rivets and the remainder by the shearing of the rivets themselves. The effective smallest diameter of the pipe is about 28⅝ in.

The pipe was coated with an asphaltic mixture having fairly satisfactory adhesion; yet a severe blow would cause it to crack off. In practice, after placing and riveting, the injured surfaces were first coated with paraffin paint and then covered with an asphaltic mixture applied hot. Very few, if any, old abrasions were to be found upon this line. Fresh abrasions at points of rupture showed a perfectly, clean, black, rustless surface. This fact is especially interesting and valuable since the pipe was laid nearly thirty years ago. Except at stream crossings the pipe was placed in the black or yellow adobe soil with its crown from 2 to 4 ft. below the surface. Streams were generally crossed on trestles carrying wooden protective flumes placed around the pipe. An examination of the interior of the pipe at several places showed that the metal was but very slightly corroded and was free from prominent tuberculations.

All observed cases of injury sustained by pipe lines as the result of severe oscillation, or vibration, occurred at points where the pipes were carried on trestles; usually across marshes or similar deposits of soft and jelly-like material, but in some instances at stream crossings where the ground was firm.

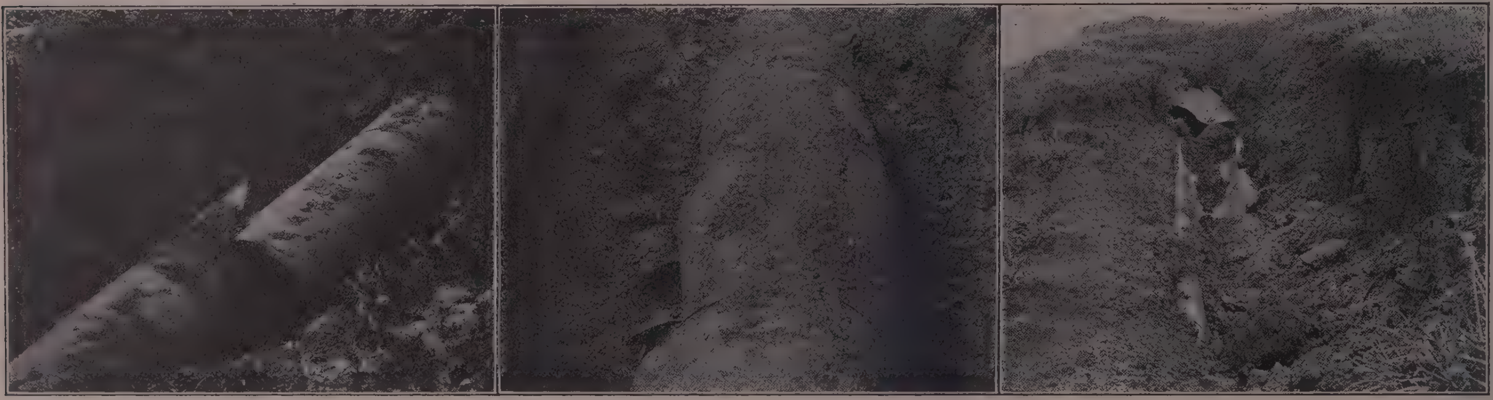
San Andreas Pipe.—Up to the present time, May 10, the only long pipe line supplying San Francisco is that known as the San Andreas, originally planned to convey water from the reservoirs of that name to the middle-level district of the city. This pipe was everywhere considerably removed from the fault which produced such havoc in the case of the Pilarcitos pipe above described. So far as the writer is informed, the San Andreas pipe received injury at but one point, where it crossed low, soft ground on a trestle whose vibration was of such amplitude as to cause rupture of a few joints. With greatest possible energy and rapidity these were temporarily repaired by the use of rubber gaskets and straps or saddles tightened by bolts through lugs on the bands.

Crystal Springs and Alameda Creek Pipe.—This pipe, 44 in. in diameter, of riveted wrought iron, is said to have a capacity of 20,000,000 gal. daily. It is designed to convey water from the Crystal Springs and Alameda Creek watersheds to the low-service district of San Francisco. At several places along its course, low, soft ground is encountered; where this condition is met, the pipe is usually elevated on a trestle whose foundations are adapted to the location.

The most notable construction of this sort is to be found on the road leading northerly from San Bruno to South San Francisco where the pipe crosses an arm, about 2,000 ft. in width, of a salt marsh. The trestle bents at this place were erected 14 ft. apart, and rested on sills, in turn supported by piles driven to firm bearing, which in some cases was only secured at considerable depths, say 40 ft. Between bents the pipe supported itself as a beam. The bents were stiffened in the direction of the pipe by the pipe itself and by heavy guard stringers and a wooden cover protecting the pipe from the sun. The effect of the earthquake was very pronounced in the soft material of the marsh and oscillations of such amplitude were induced that the alignment of the pipe was destroyed and finally one section, 400 ft. in length, was ruptured and thrown from the trestle, carrying with it the guard timbers and cover. The timber in the sills and bents was erected 21 years ago and was in a good state of preservation. This entire section is undergoing repair. A new design of trestle is being employed, whereby the pipe will have an opportunity to move laterally a total distance of 4 in. before it comes into contact with the guard stringers. Whether or not this mode of construction will be more satisfactory in the event of another severe earthquake remains to be seen. If the vibrations continue for a comparatively long time, say one and one-half minutes as in the last case, it seems probable that at length the pipe will vibrate synchronously with the earth until the inertia, as in the present instance, is sufficient to destroy the alignment and produce rupture of the joints. A rough calculation will show that the weight of one section of the filled pipe between bents is at least 5.5 tons. It is evident that the inertia which may be developed in masses of this weight extending over a long series of such bents must be very great, especially when it is realized that the ends are attached to portions more or less rigidly fixed in firm material whose rate and manner of vibration is perhaps quite different from that of the pocket of soft material in the typical marsh in question.

These remarks are possibly sufficient to indicate something of the extent and difficulty of one of the many problems which confront the waterworks engineer in locating pipe lines in regions subject to earthquakes. A primary function of any public water supply requires absolute dependability at all times.

Alvarado Force Main.—This pipe is connected with the Contra Costa Water Co.'s system supplying the city of Oakland. Some three years ago, about one mile of this line failed and was replaced by a 24-in. riveted steel pipe, supported by a trestle. In this section a 24-in. valve was located and a concrete pier was provided as a support. The earthquake threw this pipe out of alignment into a decidedly sinuous location for a distance of about one-half mile. The flanges of the gate valve were broken by the unequal set-



Views taken on the Line of the Pilarcitos Pipe.

The first picture shows the injury at a place where the line of the fault crossed the pipe at an angle of 45 deg. The pipe was torn apart, thrown out of alignment and telescoped. The reduction in length was 40 in., and the throw from alignment about 20 in. The second picture shows a series of breaks near where the fault crossed the pipe line diagonally. The third picture was taken at a place where the fault coincides in direction for a considerable distance with the line of the pipe; the picture shows 55 ft. of collapsed pipe.

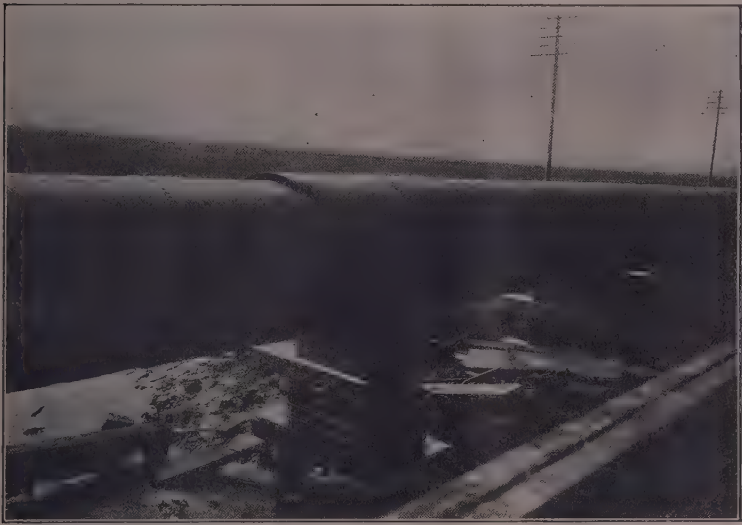
tlement of the trestles carrying the pipe and the concrete pier on which the valve rests.

Water Towers and Tanks.—These structures may be classed as of a type where failures were caused by vibrations alone. Although the data are not yet assembled, it is now clear that a very general destruction of railway and other tanks resting upon iron or wooden supports was caused in the region about San Francisco Bay by the earthquake.

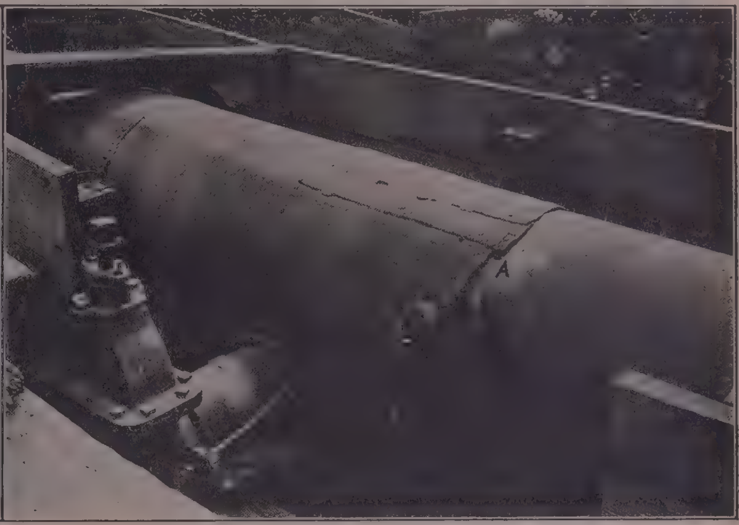
Perhaps the most important case of failure was that of the steel water tank, 90 ft. in height, at Santa Clara. The tank was supported on four braced steel columns to each of which it was attached by four ½-in. anchor bolts. The vibration and swaying of the structure sheared these bolts and, without other support, the tank fell and was destroyed.

Pipes Destroyed by Unequal Settlement.—Wherever filled ground existed, settlement in greater or less degree took place as the result of the tremblor. Pipes passing from comparatively firm and incompressible earth into such softer materials or vice versa, suffered considerably. This effect was particularly noticeable in San Francisco on account of the large number of places where such conditions were to be found.

Probably at no point were more serious results produced than on Valencia St., between 18th and 19th Sts., already described in connection with street and sewer problems. Two very important distribution mains were located at this point and were, of course, ruptured. One of these pipes, 22 in. in diameter, supplied the higher districts of the city; the other, a 16-in. pipe, was an important artery of the system furnishing water to the business section. With very commendable rapidity the Spring Valley Co. installed temporary connections across the depression produced in Valencia St. to the uninjured pipes beyond. The injury sustained at this place is significant in that it emphasizes a typical condition which must be successfully controlled in the future if similar disturbances are not to result equally disastrously. This case is but one of very many similar instances occurring throughout San Francisco.



The Crystal Springs and Alameda Creek Line.



Telescoped Pipe on the Pilarcitos Line.

The first picture shows a telescope action of 2¾ in. on a low trestle across a salt marsh. In this vicinity a length of 400 ft. of pipe was thrown partly off the trestle by the earthquake. The injury shown is typical of conditions at other trestles across soft places. The telescoping shown in the second picture amounts to 41 in., and occurs on a trestle over a small gulch. The blow-off is attached to the piece of pipe driven inside the other. The iron at A, where the pipe coat is peeled off, is perfectly black and rustless.

Outside of San Francisco, on the east side of the Bay, but very little injury was sustained by distribution systems.

Southward, in the vicinity of Palo Alto, where the effects of the earthquake were very pronounced, it is interesting to observe that the long 12-in. cast-iron pipe, known as the Searsville line, supplying the Leland Stanford, Jr., University, was broken in three places and in addition received many smaller cracks, principally along the bottom.

General Observations.—It is difficult at once to grasp the fearful significance of the destruction of certain main conduits and important distribution pipes of the system of water supply of San Francisco. Evidently the solution of the problems, in great variety, presented by this catastrophe is not easy. The whole situation demands the earnest consideration of engineers and a careful investigation of the conditions which have prevailed in the past and are likely to conspire to create serious difficulties in the future.

There are certain phases of this general matter to which attention might well be directed at this time. For instance, the good results secured at the works of the California Electrical Co., on Folsom St., from the use of water stored in a tank above the roof of their building, suggests very clearly the value of such independent supplies, especially during large conflagrations. This procedure is common in some large cities.

The extended water front of San Francisco and the arrangement of main thoroughfares leading therefrom make it possible to install without excessive cost a very effective fire system. Although not naturally so well adapted to such an undertaking as New York, San Francisco is fully as fortunate in this respect as Boston and Philadelphia, where salt water systems have already been introduced. Without question steps should be taken immediately to design and construct such a system in order that it may be in effective use by the time that the erection of the new city is well under way. In connection with such a system, the writer knows of no more desirable and necessary adjunct than a complete and efficient fire-boat patrol. If this is inaugurated, expensive local pumping plants for fire service can perhaps be avoided and an opportunity will be given for direct connection to comparatively short main lines of pipe leading directly and independently from different points along the water front to different parts of the business section.

Until a careful investigation has been carried out and the results have been made available, it does not appear wise to discuss at length a remedy which will obviate future disasters to distribution systems due to earthquake disturbances. At this time two courses of action suggest themselves. In order to prevent serious consequences due to local settlement, it appears that certain independent mains leading to all portions of the city might be located so as to pass almost wholly through comparatively firm ground. However, such a construction would probably not be completely possible. Where the passage from firm to soft material or vice versa cannot be avoided, it seems well to consider some entirely new arrangement for important pipes comprehending reinforced concrete conduits in which supports shall be provided to allow of considerable distortion. The pipes themselves might have flexible joints at intervals. It seems clear that all important lines should be independent of service connections, they should be abundantly provided with valves at all important places and cross-connections should be generally and strategically made. In addition to these pipes, the usual gridiron system should exist.

In view of the recent destruction of main conduits on the San Francisco peninsula and elsewhere, the earthquake should be effective in causing a very careful inquiry into the general policy and the fundamental details of the future great systems of water supply for San Francisco and the other cities about the Bay. It is evident that extremely long pipe lines, such, for instance, as those which might bring water from the Sierra Nevada Mountains, may become very potently dangerous if they are not designed, located and constructed with most painstaking care and technical ability. Undoubtedly such conduits should be constructed in multiple, widely separated and generously provided with cross-connections. Perhaps even further precautions would be necessary. In any event the whole subject, with its attendant problems is one of such vast importance that it should be entered upon thoughtfully and with a full knowledge of all the conditions which prevail to-day and will be likely to obtain in the future.

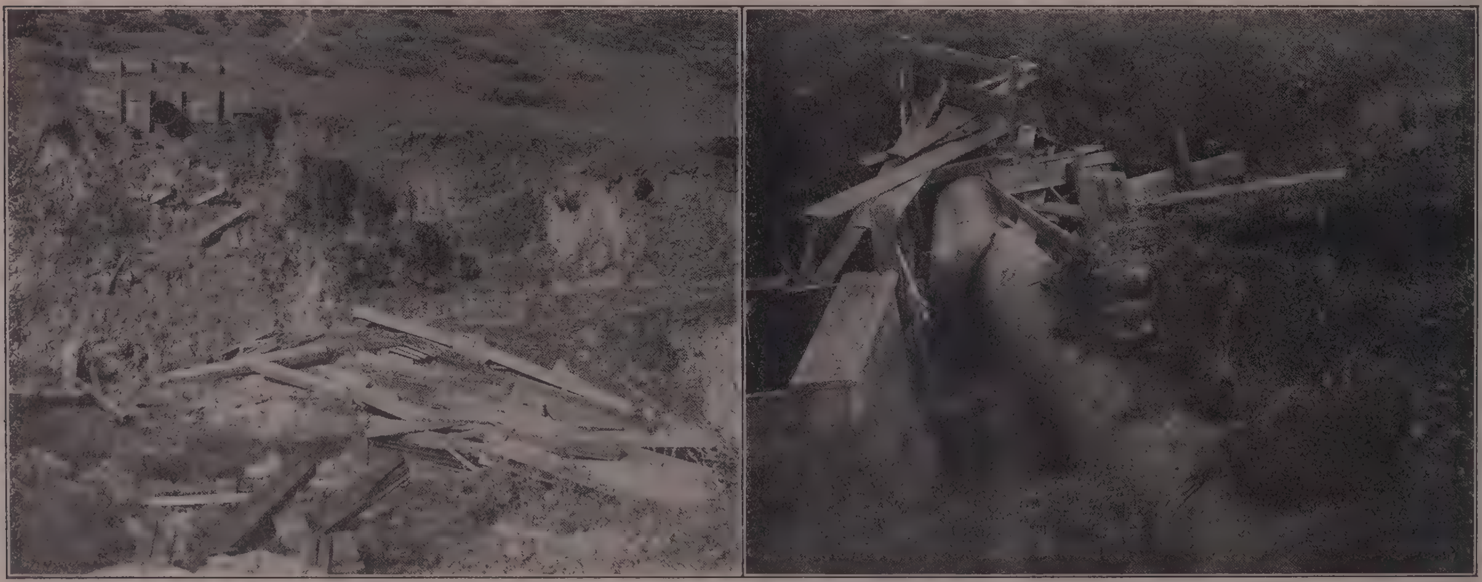
The Garbage Problem.—Among the complications almost unexpectedly induced by the earthquake and the fire in San Francisco, was that connected with the collection and disposal of garbage and other refuse. Even had the fire not occurred, the problem would have been almost as complex since the means of disposal was temporarily removed by the partial destruction of the incinerator plant by the tremblor itself.

The garbage and refuse of San Francisco is collected by an association of licensed scavengers operating under the rules and regulations of the Board of Health. By city ordinance, all garbage and domestic refuse, including ashes, must be removed by these scavengers to one point only, the destructor plant located at the corner of Kansas and Alameda Sts., in the Mission district, on the shores of the old Mission Bay, long since filled in and thickly built upon. It is probable that the homes of a very large number of scavengers were destroyed; at any rate, it is evident that the entire system of collection must have been disorganized and rendered inoperative for a few days succeeding the fire.

The destructor plant consists of 32 Thackeray cells in two batteries, each having two series of eight cells, back to back. Throughout the length of each battery, a very large semi-circular brick flue, 14 ft. wide, at the base and 10 ft. 9 in. high leads to the great chimney already described on page 704 of the issue of June 9. The earthquake threw down a portion of the brick side and gable walls of the feeding galleries above the furnaces and injured the upper walls of certain of them. No apparent injury was sustained by the main flues just referred to or by the lower portions of the furnaces, including the grates and ash chambers. The greatest damage and that which put the plant out of service was the rupture of the chimney and the destruction, by the falling materials, of the flues at their junction with the chimney.

As already shown, the upper part of that portion of the chimney which is still standing, is in a somewhat precarious condition and will probably require to be torn down. Owing to the large amount of fine incombustible ash which checks the draught and makes it difficult to consume the combustible materials, a very strong draught is necessary. It is doubtful whether the garbage and refuse recently collected in San Francisco could be destroyed with such draught as might be produced by the chimney in its present reduced height. There are three possible courses of action: One, to rebuild the chimney to its former elevation; another, to install a forced draught system and cut the present chimney down to a point where no serious injury has been sustained; the third, as a temporary expedient, to equip each furnace with a gas or oil burner and use either of these fuels to complete the combustion. Hitherto no fuel has been used and the destruction of the garbage has been accompanied by the rapid burning of its own combustible matters. The writer has made several trips in the past to the plant and has generally found that the clinker and ash taken from the furnaces contained but little, if any, organic matter capable of putrefaction.

The problem of dust and smoke prevention seems never to have been satisfactorily solved, although sprinklers had been placed in the main flues near the chimney for the purpose of washing the objectionable matters from the gases passing from the plant. These washers were not in operation on any occasion of the writer's visits to the plant. On clear days, from North Berkeley, 11 miles away, across San Francisco Bay, this chimney with its burden of smoke and ashes could be observed as perhaps the most prominent feature of the city, with the possible exception of the Great Fairmount Hotel on Nob Hill. In consequence of these facts, the plant has been a decided nuisance in the neighborhood. Although perhaps originally well located, it is now no longer advantageously placed since it is in a district rapidly increasing in population and in value as an industrial center. On the whole, although the plant suffered damage from the earthquake alone and not destruction by fire, it appears that this is an excellent opportunity to remove these works to some locality which, from every point of view, will be more satisfactorily situated. In America we have not yet reached such a stage in municipal sanitation that it is allowable to place the refuse incinerator adjacent to the City Hall.



Two Views of the Effect of the Earthquake on Trestles on the Pilarcitos Pipe Line.

The trestle in the first picture was about 100 ft. long and had a minimum depth of 25 ft. This point is fully one-fourth of a mile east of the fault, proving that the trestle was destroyed by the oscillations of the earthquake. The second view was taken at the trestle crossing of a small gulch. The pipe was here bent back on itself and telescoped, representing a reduction in length of about 40 in. The blow-off casting with its valve was ripped off. The pipe was thrown out of alignment about 12 to 15 in.

Meanwhile the problem of providing temporary means of refuse disposal has been pressing upon the city. With great energy the collection system was reorganized and re-established, barges were commissioned, wharfage facilities were obtained and the disposal of garbage and refuse was arranged for by dumping at sea. This method will doubtless be continued until a new or the repaired existing destructor plant can be put into service.

During the first few days succeeding the earthquake, it was very difficult for the authorities to control the collection and disposal of garbage. Almost immediately, however, carefully devised regulations were issued by the Board of Health and these were enforced by military authority, the entire city being under martial law. At the present time it is believed that the collection system has been thoroughly rehabilitated and that the temporary method of disposal at sea is in satisfactory operation.

The Problem of General Sanitation.—Through the devastation of a very large part of the city, estimated at four square miles at least, thousands, possibly hundreds of thousands, of people were driven from homes which had collapsed from the effect of the earthquake or had been consumed by the fire. Some of these people found their way more or less quickly across the bay and were cared for by Oakland, Alameda and Berkeley and other places in this region; some found homes with friends in undisturbed portions of San Francisco; some, through the generous co-operation of the railroads, which issued free transportation, traveled to the interior of the state or have scattered throughout the Pacific Coast, northward to Oregon and Washington, southward to Los Angeles and San Diego. But the great majority retreated to the public reservations, principally the Presidio and Golden Gate Park. Here they were huddled together without individual means of providing themselves with adequate shelter and food. For these, primarily, the magnificent generosity of the entire United States and of foreign countries has given the material aid most eminently necessary. Among other problems, that of sanitation required to be solved and solved quickly. Many of those who were forced to the public parks were ignorant of the first laws of public or even personal hygiene.

In great camps such as those which sprang into immediate being, the danger of the spread of infectious disease is very great. The experiences of the United States troops during the recent Spanish-American War demonstrated beyond peradventure that heavy mortality may result from any failure to observe the laws of sanitation with respect to water and food supplies, to isolation and to general preventative medicine.

The water supply obtained by the people congregated in these public places was necessarily derived from local sources. In the Presidio, the regularly established supply from deep wells is believed to have been sufficient and satisfactory. In Golden Gate Park, the supply was obtained from Stow Lake whose watershed appears not to have been patrolled or otherwise protected from the pollution which was so likely to arise under the existing conditions. In all other parts of the city where the public supply was cut off, resort was had to private wells, sunk in the sand everywhere constituting the surface material of considerable depth. Naturally, sand is better adapted to furnishing purified water than any other material, but in this instance it was frequently saturated with sewage and cesspool drainage, especially after the not infrequent destruction of local sewers and house connections. The Board of Health immediately instituted a system of chemical examinations of these wells and in many other ways did what it could to prevent the spread of disease from this source. Instructions were issued to the effect that all drinking water should be boiled until the public supply should be reinstated within the district in question.

The disposal of night soil in public parks was effected by the use of ditches dug in the sand. Over the contents of these chloride of lime was frequently spread and coverings of sand were successively placed. In the streets latrines were generously provided. They were usually placed over manholes of the sewerage system; occasionally, however, they were unfortunately located over catch basins or sewer inlets, whence the night soil might not reach the main sewer lines for some time.

The disposal of garbage and refuse has already been alluded to. Cans or other receptacles were provided as soon as possible in public places and their contents were removed by collectors detailed for the purpose.

It seemed to be a necessary accessory of the appalling conditions of every sort engendered by the San Francisco catastrophe, that persons with infectious diseases should be driven from their homes together with those who were well. It is difficult for one removed in place and time to appreciate the full significance of this intermingling of the lame, the halt and the blind, the diseased and the well. With what now appears to have been almost incredible energy, isolation camps and hospitals were established where necessary, and all who were sick were cared for in the best manner possible under the circumstances. Vehicles of every description bearing the Red Cross were to be seen performing errands of mercy throughout the city. Without question, some cases of infectious disease of dread character escaped and may produce their sad effects; but as a rule this sort of thing was largely eliminated.

The well-nigh universal injury or complete destruction of house chimneys made it necessary to prohibit their use altogether until an official inspection could be made and a certificate of fitness issued for each. This procedure required that all cooking, by rich and poor alike, be done in the streets, usually only in the shelter of hastily erected booths. The foods so prepared were almost always exposed to dust and its attendant dangers so well known to the sanitarian. More than any other diseases, tuberculosis from sputum on streets and sidewalks and typhoid fever from flies are to be feared from such exposure.

What the real sanitary result of this calamity will be cannot be estimated at the present time. Enough has been said, however, to show that the authorities were alive to the situation and earnestly attempted to prevent the spread of disease. Among the circulars issued by the Board of Health during the trying days immediately succeeding the fire, the following may be of interest:

"All water should be boiled, whether for drinking, bathing or cleansing purposes. Use no unboiled water in the preparation of food for cooking or baking. Use unboiled water only for flushing purposes. This order applies to all water, whether Spring Valley, lake or well water.

"All milk should be boiled, whether used by infants or adults.

"Food in cans should not be allowed to stand uncovered, lest it become tainted or infected.

"Do not eat uncooked vegetables.

"All butcher shops and bakeries should be screened.

"Remove all garbage, animal and vegetable refuse from your premises and put into garbage barrels at the curb line of street and cover the same with chloride of lime daily.

"Seal all toilets and other plumbing fixtures in houses where side sewers are broken or disconnected.

"Screen all windows, doors and other openings to prevent the entrance of flies, as they are carriers of filth.

"District sanitary inspectors will report location of latrines to the captain of the district daily, so that the same may be inspected and properly disinfected.

"Any person whatsoever having knowledge of the presence of these diseases should report the same to a physician in his neighborhood, as every physician in the city is now a sanitary inspector. And such physician upon receipt of this notice should inspect the case, and if verified by him, report the same to the headquarters at the Park Emergency Hospital, Stanyan and Waller Sts., or at the temporary headquarters of the Board of Health, Grove and Laguna Sts.

"A strict observance of these instructions will positively prevent the spread of any of these diseases. For the safety of all, most careful reports of all contagious or infectious diseases should be given to the district inspectors."

The induced problems of sanitation were extended to other cities. Very shortly after the fire, when the refugees began to pour into Oakland, Alameda and Berkeley, these cities began a superficial but reasonably effective inspection, at the ferry wharves in San Francisco, of those obtaining passage across the bay. In this way it was hoped to debar those who were obviously suffering from pronounced infectious diseases. It was impossible to detect incipient cases.

It fell to the writer's lot to have somewhat to do with the sanitation of refugee camps established on the grounds of the University of California within and in the neighborhood of the California Football Field. To all inmates of these camps, cards of admittance were issued. Others, except those in official control, were not allowed to enter unless with good excuse. In general no one was permitted to remain in the camps without having had a bath and without a certificate of medical inspection made in connection therewith. Suspected cases of disease were sent to a small detention camp established for the purpose.

Food was served in the University grounds at some distance from the camps. The commissariat department early adopted rigorous sanitary measures with respect to the quality of food, sterilization of cups, knives, forks and spoons, cleanliness of grounds, disposal of garbage, prevention of flies, etc.

Within the camps water closets or latrines connected with sewers were provided. The seats of the toilets were cleaned very frequently and washed with corrosive sublimate and flushing of the latrines was regularly carried on. The toilets and baths of Harmon Gymnasium for men and of Hearst Hall for women were opened for the use of the refugees, and skilled attendants and medical inspectors were placed in charge. For night use, urinal pails were provided throughout the camp at intervals along the main streets, the arrangement of tents being in military order. These urinals were emptied and sterilized every morning and stored apart during the day.

Rigid rules governing the bringing of food into the camps, the maintenance of tents, the airing of bedding, etc., were at once established and were enforced under the direction of the sanitary inspectors in charge of the camps both day and night. Practically all of the sanitary work in connection with the camps was directed or performed by members of the University faculty.

The Earl's Court Wheel, which is the British equivalent of the Ferris wheel recently destroyed at St. Louis, is to be pulled down after a very profitable existence of eleven years. It was even more elaborate than its American prototype and its construction aroused as much attention among engineers in Great Britain as that of the Ferris wheel did here.

Sinking Test Wells with Rotary Boring Machines.

The desirability of making accurate borings on the sites of dams and similar structures previous to construction is well recognized, but the cost of making them with diamond drills precludes the use of this method in many pieces of work and necessitates the adoption of the wash-drill process. Under certain conditions the results obtained with the latter are questionable, and to remedy this condition of affairs a method of securing accurate data from borings through practically any kind of soil or rock, at about one-fifth the cost of diamond-drill borings and with no increase in labor costs, has been developed during recent years by the American Well Works, of Aurora, Ill. Where the rock is overlaid by earth, sand or clay formations, a rotary boring machine is used in connection with a vacuum sand pump, until the rock is reached. A hollow soft-iron bit is then used in the rock, with a small amount of finely divided and specially hardened steel particles.

The rotary machine is operated in connection with a regular well-drilling derrick and hoisting engine. It has an adjustable clamping device around the top of the pipe with which the bore is cased. This device and the casing revolve on a horizontal gear. The pipe is suspended from a fall line on the derrick and may be raised and lowered, the clamping device bearing against it through four small wheels. The pipe is capped and fitted with a hose through which water is supplied under pressure. The lower end of the casing carries a thin boring bit which cuts its way through the material encountered as the casing is revolved. When a core of the formations being passed through is desired only enough water is supplied to the casing to work the materials into a semi-liquid condition. After a proper depth has been reached, this semi-fluid core in the casing of the bore is removed with a vacuum sand pump, which is very different in construction from the ordinary sand pump.

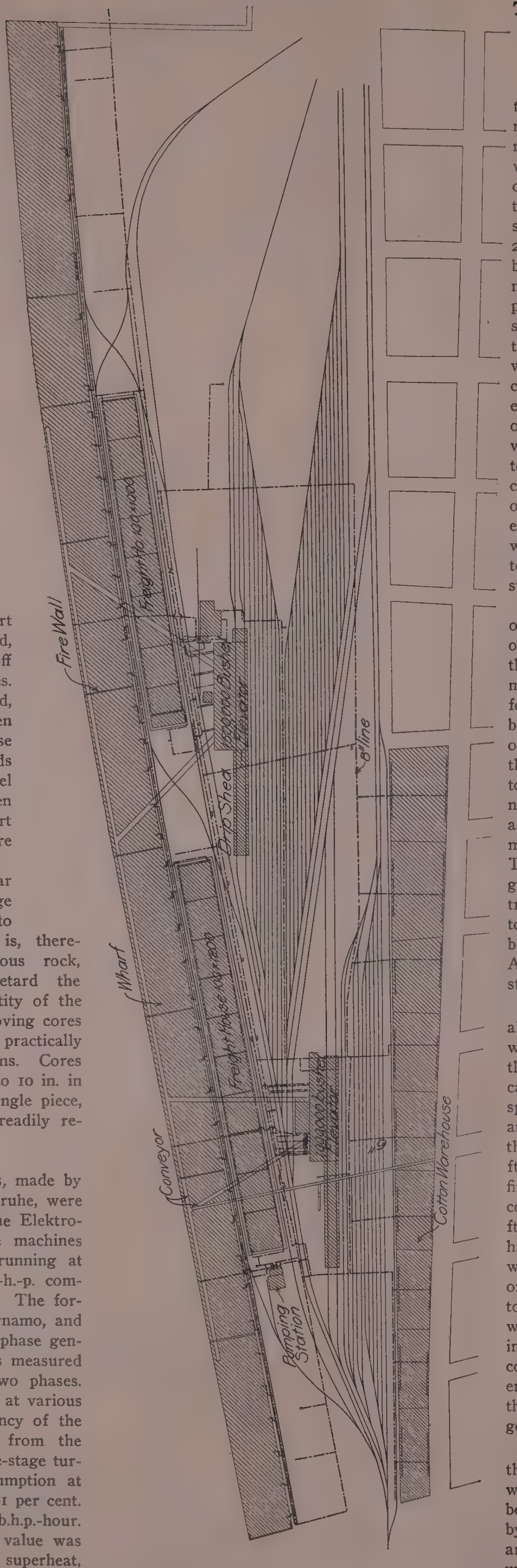
This pump consists of a cylinder, about 5 ft. long, which carries a plunger that travels its entire length. The plunger is forced to the lower end of the cylinder by the heavy plunger rod as the pump is lowered into the bore. When the pump reaches the required depth, the plunger is drawn up rapidly by a cable on a reel at the ground surface and a portion of the material in the bore drawn into the cylinder. The lower end of the latter is fitted with a valve which closes automatically. This valve can be released from its closed position by the operator, when the pump has been drawn to the surface. The contents of the cylinder may thus be drawn from the bottom of the cylinder, a hinge in the upper portion of the latter and in the plunger rod permitting the pump to be held at a slight angle while discharging.

The process of drilling and removing this semi-liquid core is continued until the rock or other dense strata are reached, when the boring is continued with the soft bit and the particles of steel. This bit is a soft-iron tube of any convenient length. Its upper end is contracted to permit threads to be cut in it for the attachment of the coupling on the drill rods used in turning the bit, and the bottom end has two short vertical slots, diametrically opposite. The outside diameter of this tube is slightly larger than the coupling on the drill rods and the inside diameter is ⅛ in. larger than the core desired. The drill rods are hollow and water is supplied to the bit through them. The steel particles used in connection with the bit are about the size of the largest grains of torpedo sand. They are thrown loose into the tube through the drill rods, about a double handful being supplied at a time. The bit is made quite soft on the lower end and is revolved at good speed, causing the particles of steel to adhere to it. The bit and these particles thus act as a coarse file, which has been found to cut through rock of practically any density.

In cutting through dense strata, the drill rods are occasionally raised slightly to change the relative position of the steel particles around the lower end of the hollow bit. The tool cuts an annular channel through the strata, a small quantity of water being forced down the boring rods to facilitate the cutting. The size of the core most readily removed depends on the formation, softer formations such as coal and shale being best taken out in cores not less than 3⅝ in. in diameter. No diameter of core less than 2⅜ in. is recommended, although 1⅜-in. cores have been cut successfully. The length of core removed at each operation also depends on the formation, cores from a few inches to several feet in length being taken out. An additional supply of water is admitted for a short time just before the core is removed, after which the water supply is shut off and the bit rotated for 1 or 2 minutes. The rods and bit are then removed, the core coming out in the latter. When large cores are to be removed the hose connection on the upper end of the rods is removed and a handful of fine gravel dropped into the bit. Water is then supplied to the bit again for a short time, without turning the rods, before the core is removed.

The particles of steel do not wear out to any extent, but they will lodge in crevices and may be crowded into soft strata and lost. The process is, therefor, most successful in homogeneous rock, but the crevices only slightly retard the work and require an additional quantity of the steel particles. These outfits for removing cores from drill holes have been used in practically every kind of soil and rock formations. Cores of dense rock 3 to 5 ft. long and up to 10 in. in diameter have been taken out in a single piece, while coal and shale are nearly as readily removed.

Tests of Elektra Steam Turbines, made by the Electrical Industries Co., of Karlsruhe, were recently reported in the "Schweizerishe Elektrotechnische Zeitschrift." One of the machines was a 45-h.-p., single-stage turbine running at 3,500 r.p.m., and the other was a 60-h.-p. compound turbine, running at 3,000 r.p.m. The former was belted to a direct-current dynamo, and the latter direct connected to a three-phase generator. The output of this latter was measured by means of a wattmeter between two phases. The steam consumption was measured at various loads and also at no load, the efficiency of the electrical machines being calculated from the various separate losses. For the single-stage turbine the most favorable steam consumption at 10.2 atm. abs. and 286° C. superheat, 81 per cent. vacuum, and 56 b.h.p. was 26.4 lb. per b.h.p.-hour. With the compound turbine the best value was 19.8 lb. per b.h.p.-hour at 10 atm., 238° superheat, and 87.5 per cent. vacuum. The turbine is said to be the most compact of any type, the 60-h.-p. size being only 130 x 110 cm., and 150 cm. high.



Stuyvesant Docks, New Orleans, La.

The Stuyvesant Docks of the Illinois Central R. R. at New Orleans.

The new Stuyvesant Docks of the Illinois Central R. R., at New Orleans, form one of the most complete and modern tidewater freight terminals in this country, occupying a 90-acre site, with a frontage of about a mile on the left bank of the Mississippi River. The buildings, elevators and wharves of the original terminal on this site were completely destroyed by fire on Feb. 26, 1905, the total loss being estimated to have been $3,000,000. The structures of the new terminal have been built as nearly fireproof as it is possible to execute their construction with a reasonable financial expenditure, the more important structures conforming with the fire underwriters' requirements. The original terminal included 600,000 sq. ft. of wharf; three import and export freight warehouses having a floor space of 400,000 sq ft.; two export grain elevators, with capacities of 1,000,000 and 1,500,000 bushels, together with the drying houses, conveying machinery extending to and along the wharves, and other equipment necessary to handle the heavy export grain traffic of the Illinois Central R. R., which is entirely tributary to this terminal. The terminal also included a freight receiving and storage yard containing over 15 miles of track.

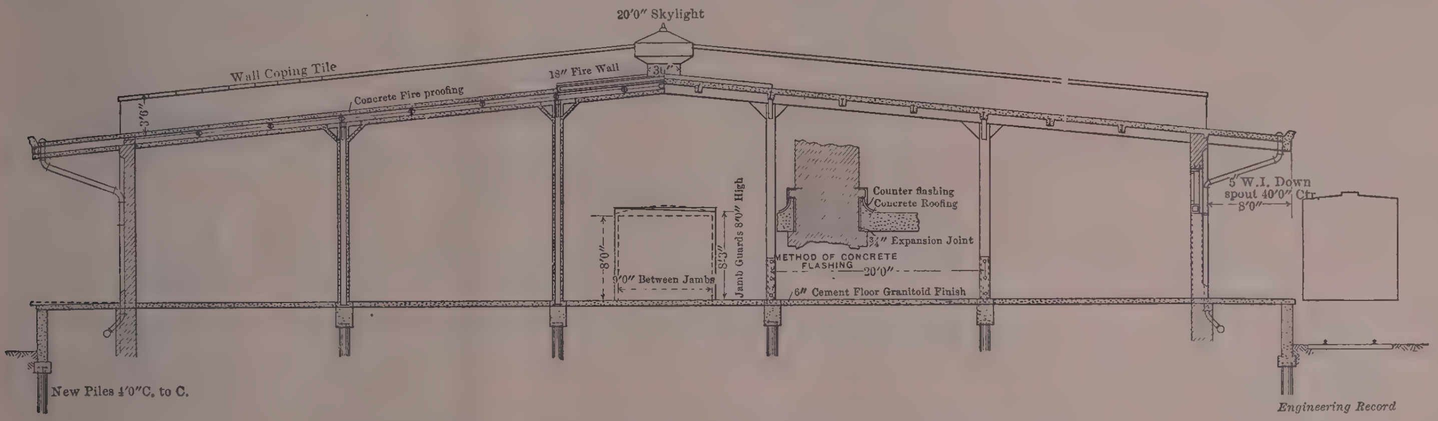
The site of the terminal is 660 ft. wide at one end and 1,320 ft. wide at the other. The original wharf extended along the river front of the site. Just back of this wharf and toward the middle of the site were two large warehouses for export and import freight. Some distance back of these warehouses were the two elevators, one near each end of the two warehouses. On the rear line of the site and back of the elevators was a very large cotton warehouse. The new terminal has the same number of buildings as the original one, and their relative arrangement is the same in the new as it was before. The capacity of all of the structures has been greatly increased, however. The length of the tracks in the terminal yards has been increased to over 23 miles, and many other changes have been made to facilitate the handling of traffic. A complete system of water supply has been installed for fire protection.

The conveyor belts which extended to and along the original wharf from the two elevators were placed in wooden housings on timber trestles. The fire which destroyed the terminal caught in one of these housings and was rapidly spread to the various buildings by the housings and by a strong wind that was blowing. One of the wharf legs of the conveyors ended about 1,230 ft. from one end of the wharf. A transverse fire wall in the latter just beyond the end of the conveyor stopped the fire and saved about 1,230 ft. of the wharf. This portion of the old wharf has been included in the new terminal. A new wharf, 3,550 ft. long and from 135 ft. wide at one end to 152 ft. at the other, has been built to replace the old wharf. One end of this new wharf is connected with one end of the remaining portion of the old wharf, thus forming a continuous structure nearly a mile long. The entire wharf has a covered floor space of more than 15 acres and berth space for 14 large seagoing vessels.

General Design.—The portion of the old wharf that was saved is built on piles, has a heavy wooden floor and a wooden roof carried on timber roof trusses. It is divided into two sections by a transverse fire wall, and is completely separated from the new wharf by a transverse fire wall. The new wharf is also built on piles. It has a heavy timber floor and is covered with a reinforced-concrete roof carried by a structural-steel frame built up on the piles. The piles and all timbers of the sub-structure of the new wharf, including the floor joists, are creosoted. The new wharf is divided transversely into seven sections by self-sustaining 18-in. brick fire walls, one section 605 ft. long, three sections 500 ft. long, one 506 ft. long, one 461 ft., and one 408 ft. long. The fire walls are on concrete footings on piles, the concrete being carried down below low water in the river. They extend 4 ft. above the roof line and have longitudinal wing walls, 21 ft. long, at each end. The openings in these walls are fitted with automatic sliding fire doors. The sides of the wharf are not enclosed, but the freight stored on the wharf is protected from the weather by heavy tarpaulin curtains along each side of the latter.

The piles in the sub-structure on which the wharf is built are in regular transverse and longitudinal rows, the rows being generally 10 ft. apart on centers in both directions. The longitudinal rows of piles are capped and the floor joists are placed on these caps. The piles in the wharf are from 40 to 100 ft. long, averaging about 65 ft., and are, without exception, in one piece. In all, 7,000 piles were required in building the sub-structure of the new wharf.

The steel columns which carry the roof of the wharf are placed in eight longitudinal rows, with transverse rows 20 ft. apart on centers. These columns are sway-braced and X-braced at proper intervals. The columns are each built up of two angles riveted together to form a star-shaped cross-section. They are incased in concrete, reinforced with a Johnson corrugated bar at each corner and bound with a spiral wire. The concrete roof is carried directly by 7-in., 15-lb. I-beam purlins on 12-in., 31½-lb. I-beam girders on the transverse rows of roof columns. The concrete roof is 3 in. thick, and is reinforced with 1¼x⅛-in. bars and cross spreaders. This roof was built by the Roebling Construction Co. and covers an area of 509,425 sq. ft. The roof is pitched 1 in. to the foot in both directions from the longitudinal center line. Three-foot openings, with 16-oz. copper globe ventilators, are placed at intervals on the center line of the roof.



Engineering Record

Cross-Section of Freight House, Stuyvesant Docks, New Orleans.

Construction Methods.—The new wharf was built in a remarkably short time. The piles on which the old wharf stood were mostly burned down to the water by the fire. The tallest stumps of piles had to be cut off, and a large amount of the freight which was stored in the old wharf, including heavy bales of cotton, had to be taken out before the piles for the new wharf could be driven. The first piles were driven April 28, 1905, and those for carrying the wharf proper were all in place by July 5, following. The sub-structure for two 500-ft. sections of the wharf was completed and floored over within 4 or 5 days after the fire occurred, in order that temporary facilities could be provided for handling the traffic coming to the terminal. The remainder of the wharf was then built in regular succession, the sub-structure and flooring being nearly all completed before the steel roof columns and framing were erected.

The piles were driven in longitudinal rows, beginning with the row on the land side. Four pile drivers were used. One of these was a floating driver mounted on a scow. It had a 5,000-lb. drop hammer, and was used in driving part of the three longitudinal rows of piles on the river side of the wharf, the stumps of the burned piles and the wreckage from the fire preventing its additional use. The other three drivers had No. 1 Vulcan steam hammers. These drivers were set on cars on a standard-gauge track along the land side of the wharf, until the first two longitudinal rows of piles had been driven and capped. The drivers were then mounted on these first two rows of piles and the remaining rows driven in regular succession.

The boiler, engine and leads of each of these three drivers were set on a platform on two heavy timber sills, about 42 ft. long, which were fastened together and braced against each other. The hammer leads were built up on one end of this pair of sills, and the engine and boiler set on the other end. Each sill was mounted on an 8-in., double-strength, wrought-iron pipe roller, which rested on the caps of the rows of piles that had already been driven. These rollers were set in bearings on transverse timbers between the sills and permitted the driver to be moved along readily as the work progressed. The end of the sills carrying the leads projected out from the last row of piles driven, so the leads were over the row in which piles were being driven. When a longitudinal row of piles was completed the driver was moved forward on the rollers and work started on the next row. The manner in which these drivers were mounted greatly facilitated the progress of the work.

The structural steel for the roof columns and frame began arriving on Aug. 1. The erection of the steel on 3,060 ft. of the wharf was started Aug. 12, and was finished in 22 days. A traveler, with a platform 30 ft. square, was used. This traveler carried a stiff-leg derrick with a 50-ft. boom at each forward corner, and was set up on the longitudinal center line of the wharf. A material distributing gang worked on each side of this traveler. The transverse roof bents were erected in three sections; the end sections of each bent were first erected and then the middle section put in place. Two transverse bents were erected at each setting of the traveler, the latter moving back on a track on the wharf floor as the erection work progressed. The work on the wharf roof was delayed for some time after the erection of the steel work, owing to the prevalence of yellow fever in New Orleans.

The handling of the material used in the wharf was one of the greatest difficulties connected with the construction of the new terminal. The wharf is separated from the two new import and export freight houses by a space wide enough to accommodate only two tracks, and all of the materials required for the wharf had to be handled on these tracks. Over 600 cars were required to deliver the piles used. About 6,000,000 ft. of squared lumber was used in the wharf, and 6,000 tons of structural steel were erected to carry the wharf roof. The brick used in the fire walls and the materials for the concrete roof were also delivered on these tracks. Two 40-ton locomotive cranes, made by the Brown Engineering Co., gave valuable service in handling these materials. These cranes were used in switching cars in the absence of a switching engine, and handled the various materials, including piles up to 100 ft. in length.

Fireproof Warehouses.—The import and export freight warehouses just back of the wharf have been built as nearly fireproof as it is possible to construct them, the wood in the body of the metal-covered automatic sliding fire doors being the only inflammable material entering into their construction. The original buildings on the sites of these two warehouses were built of brick and had wooden roofs carried on timber frames. The walls of these buildings were built on heavy brick footings and their floors were laid on a sand fill brought up to the floor level. In fact, a considerable part of the whole terminal is on a fill, made with sand pumped in from the river. The footings of the old buildings were mostly intact and have been included in the footings for the new fireproof structures.

The new buildings have concrete floors, brick walls and reinforced-concrete roofs carried by structural-steel columns and roof frames encased in concrete. One of these warehouses is 100 x 1,000 ft., and the other 100 x 1,200 ft. in plan. The 1,000-ft. building is divided into one 160-ft. and seven 120-ft. sections by transverse brick fire walls. The 1,200-ft. building is divided into ten 120-ft. sections by transverse brick fire walls. Each of these sections is practically a separate structure. The concrete floors of the buildings are 6 in. thick and have a 1-in. granitoid finish. They are laid directly on the sand fill and are at the same level as the floors of the cars on tracks laid on both sides of the building. The roof columns are in 4 longitudinal rows, the columns in each section being in regular transverse rows. Each column is carried by a concrete cap on a pile driven into the sand fill. The details of the columns which are much the same as the details of the columns carrying the wharf roof, are shown in an accompanying illustration. The roof purlins are 8 in., 18-lb. and 7-in., 15-lb., I-beams. They are placed longitudinally and are carried by transverse 12-in., 31.5-lb. I-beam roof girders on the transverse rows of columns. The concrete roof over the 1,000-ft. warehouse is 3 in. thick and is reinforced with diamond mesh expanded metal. This roof was built by the General Fireproofing Co., under the supervision of Mr. C. N. J. Neville, New Orleans, manager of that company. The roof of the 1,200-ft warehouse was built by the Roebling Construction Co.

The fire walls which separate the sections of these two buildings are on concrete footings on piles. They extend from the sand fill on which each building is built to 3 ft. above the concrete roof of the building. The concrete roof slab of each section has an expansion joint at the transverse fire wall at each end of the section and is entirely separated by these walls from the roof slabs of the adjoining sections. A large skylight is provided in the middle of the roof of each section. Ventilator openings are also made in the roof. The expansion joints, skylights and ventilators have heavy copper flashings and the skylights are glazed with wire glass. A single 8x9-ft. door opening at the middle of each fire wall connects the adjacent sections of the building. Three doorways are also placed in each side of each section, all fitted with automatic sliding fire doors.

A reinforced-concrete platform, 8 ft. wide, extends around all four sides of each building. The roof framing and concrete slab are cantilevered out from the walls of the building to cover the platforms along the sides. The two tracks on the wharf side of the warehouses will serve either the wharf or warehouses. Tracks are also laid on the opposite side of the warehouses.

Grain Elevators.—The adjacent ends of the two fireproof warehouses are 420 ft. apart. The 1,500,000-bushel grain elevator is about 100 ft. back from one end of the 1,000-ft. warehouse. The 1,000,000-bushel elevator is 120 ft. back from the opposite end of the 1,200-ft. warehouse and over 1,000 ft. from the larger elevator. Both elevators are of the usual type of heavy timber construction and are covered with corrugated sheet-iron. They are built on concrete piers on piles driven into the sandy soil of the site. The machinery in both elevators is operated by rope drives, which are furnished with power by engines in a separate brick engine and boiler house at each elevator. The engine and boiler houses of both elevators are fireproof buildings, having concrete or tile roofs carried by steel framework. Both elevators are equipped throughout with dust-collecting systems leading to the furnace of the boilers.

The 1,500,000-bushel elevator is 101 x 330 ft. in plan and 180 ft. high. The cars of grain are received on two tracks in a 45x310-ft. drip shed at one end of the elevator. The two tracks in this shed extend through the elevator. Grain is elevated from hoppers under these tracks in the building by any one of seven receiving elevators, each having a capacity of 8,000 bushels an hour. This elevator is also equipped with seven elevators of the same capacity which are used in elevating the grain to shipping bins. The lateral transportation of grain on the different floors is handled by conveyor belts.

The brick engine and boiler house of this elevator was practically uninjured by the fire which destroyed the terminal. It is 60 x 105 ft. in plan and contains in the boiler room four 300-h.-p., water-tube boilers made by Aultman & Taylor Machinery Co. The engine room contains an 850-h.-p., non-condensing Corliss engine and two Knowles underwriters' steam fire pumps, with a capacity of 1,500 gal. a minute each. These pumps have two 14-in. suction mains leading to the river and are a part of the complete fire protection system that has been installed for the terminal.

The 1,000,000-bushel elevator is 83 x 283 ft. in plan, 165 ft. high, and has much the same general arrangement as the larger elevator. It has six receiving and four shipping legs, each having a capacity of 8,000 bushels of grain an hour. The power plant of this elevator is in a 40x110-ft. brick building on the river side of the elevator. The boiler room of this building contains four 300-h.-p. water-tube boilers made by the Aultman & Taylor Machinery Co. The engine room contains a 600-h.-p. compound condensing Vilter Corliss engine, direct-connected to the main sheave wheel of the rope drive of the elevator. The engine room also contains a Knowles underwriters' steam pump, with a capacity of 1,500 gal. a minute, and a Laidlaw-Dunn-Gordon underwriters' steam pump, with a capacity of 1,000 gal. a minute. These pumps also have two separate 14-in. suctions leading to the river and are a part of the fire protection system of the terminal.

The erection of the 1,500,000-bushel elevator was started March 1, three days after the fire, and was practically completed July 15, following, when grain was handled through it and through temporary belt conveyors leading to the wharf. This elevator contains about 3,000,000 ft. of squared timber and 2,000,000 ft. of flooring and siding. The erection of the other elevator building was started June 1, after the fire, and was completed about the first of the following October.

Interior of Fireproof Warehouse on the Stuyvesant Docks.

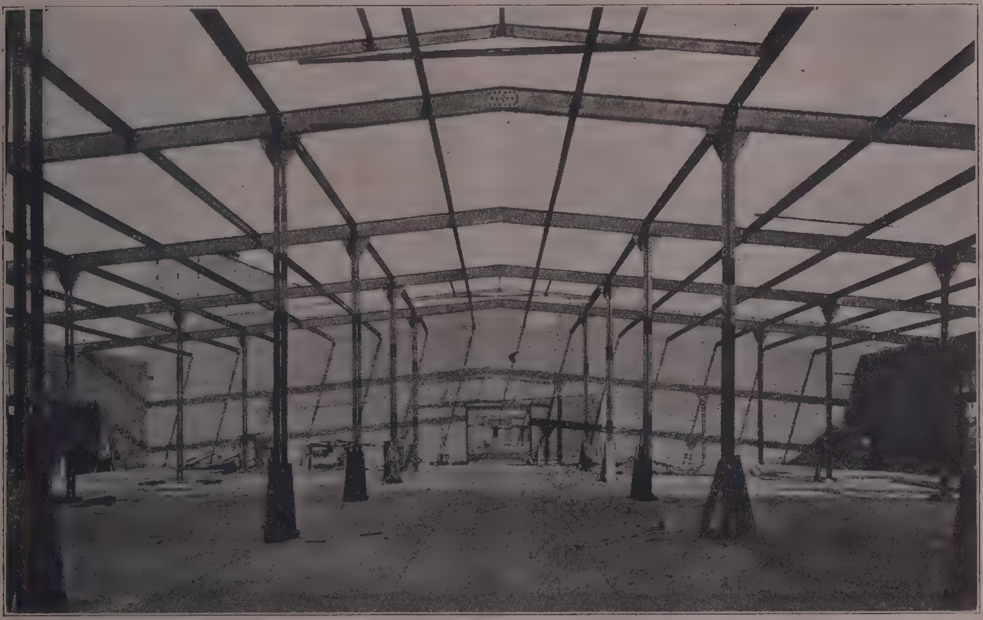
The grain is all transported from both of the elevators to ships at anchor along the wharf by belt conveyors in fireproof housing extending over the tracks, warehouses and along the wharf on steel towers. This conveyor belt system embraces over 7,000 ft. of 36-in. belt and was designed and built by the Webster Manufacturing Co., of Chicago. A gallery 2,950 ft. long extends along above the wharf on a steel frame built up on separate footings. Two galleries are extended on steel frame viaducts from each elevator to this gallery along the wharf. One of the galleries extending from the elevators to the wharf contains one, and the other three each contain two 36-in. belt conveyors, which discharge their contents on conveyor belts in the wharf gallery. The latter contains seven 36-in. belt conveyors. These seven wharf conveyors are fitted with automatic traveling tripping devices that discharge the grain from the belts into telescopic steel chutes along the wharf, which chutes lead into the holds of the vessels receiving the grain. Each of the conveyors in the wharf gallery is about the length of the largest sea-going vessels, so that seven vessels may be receiving grain at the same time. The conveyors are operated by rope drives leading out from the elevator power houses. The belts are run at about 1,000 ft. a minute. Each belt has a capacity of 15,000 bushels of grain an hour, so that the combined capacity of the conveyor system is something over 100,000 bushels an hour.

The housings in which the conveyor belts are placed are believed to be as nearly fireproof as it is possible to construct them. The elevated towers on which they are carried and the frames of the housings are built entirely of structural steel. The floor and roof of the housings consists of book tile laid on T-beams placed transversely between the sides of the housing. The roof is covered with roofing felt laid in tar and covered with shells to make it water-tight and additionally fireproof. The tile in the floor of the housing is covered with a thin coat of cement mortar. The sides of the housing are galvanized sheet iron, which is fastened to the steel frame with special clips. A number of windows are placed in the sides of the housing for ventilation, but these windows have metal frames and are glazed with wire glass.

Fireproof Cotton Warehouse.—A fireproof cotton warehouse has been built along the rear of the terminal site to replace the old cotton warehouse destroyed by the fire. The new building is of almost exactly the same type of construction as the two fireproof freight warehouses. It is 2,900 ft. long, 90 ft. wide at one end and 180 ft. wide at the other end. The increase in width, which is gradual, is due to the angling of a street on which one side of the building faces. The building is divided into sections, 240 ft. long, by transverse brick fire walls. The warehouse is built to handle and store cotton brought into the terminal by the Ilinois Central R. R., and bound to various other terminals in New Orleans. Tracks are laid along the opposite side of the building from the side along the city street.

The side of the building along the tracks is almost entirely open to a height of 10 ft. above the floor. This continuous opening is fitted with heavy fire doors suspended on rollers on tracks. The doors are arranged on two parallel sets of tracks and the doors placed alternately on one track and then the other. With this arrangement, a door may be opened at any point along the side of the section avoiding the frequent necessity of shifting the cars that is required with the usual arrangement of fixed door openings. The total length of sliding doors to each section is sufficient to permit enough overlapping of the adjacent doors for proper fire protection. The floor of the building is sloped 3 ft. from the tracks to the side along the street to assist in trucking the bales of cotton from the cars to heavy teaming trucks on which they are delivered to various parts of the city.

The structural details of the roof of this warehouse are so nearly the same as those of the roofs of the freight warehouses that the description of those roofs applies to this one. The roof, which covers an area of about 400,000 sq. ft., was built by the General Fireproofing Co. The roofs of this building, the wharf and one of the freight warehouses are covered with a special four-ply asbestos roofing, which is made by the H. W. Johns-Manville Co., and was laid by the forces of that company, the entire contract including over 10,000 squares. This roofing is composed of three layers of asbestos, three layers of asphalt cement and a single thickness of heavy canvas burlap. It is made in strips 32 in. wide and is laid on a coating of hot asphalt applied to the surface of the concrete roof slab. The roof of the cotton warehouse is pitched both ways from the longitudinal center line of building, and as the width of the building varies from end to end, the roof on one side of the center is a continuous warped surface. The design and construction of this warped surface were, of course, considerably complicated.



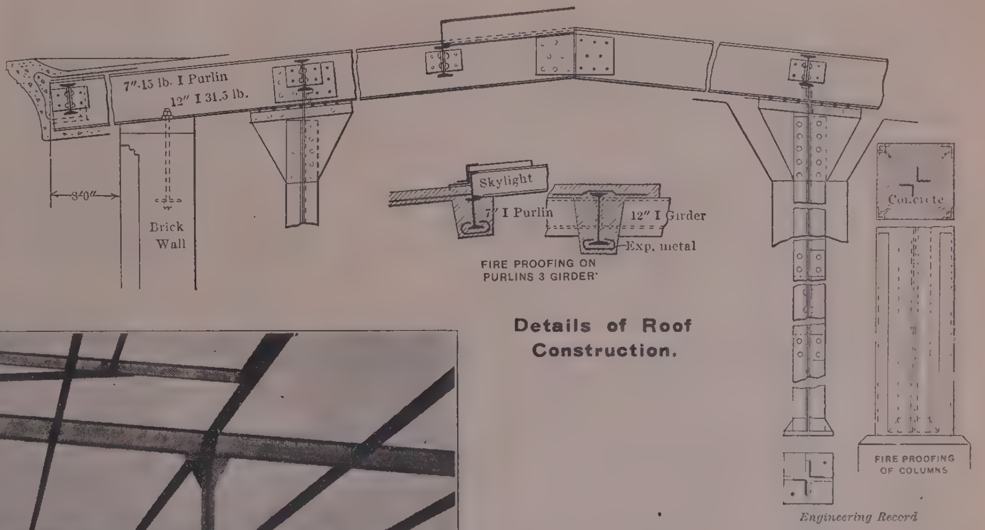
Steelwork of Fireproof Freight Warehouse on the Stuyvesant Docks.

Fire Protection System.—A separate pumping station building, containing ample equipment for furnishing water for the fire protection of the terminal, and a complete system of supply and distribution mains is included in the new terminal. The pumping station is in a thoroughly fireproof building, 45 x 60 ft. in plan, at the end of the 100x1,200-ft. freight warehouse most distant from the 100x1,000-ft. warehouse. This station contains two 6x18-in. fire-tube boilers and four Knowles underwriters' fire pumps, with a capacity of 1,500 gal. a minute each. These pumps are supplied by two separate 14-in. suction mains leading to the river. They operate against a head of 130 lb. per square inch and supply directly the system of distribution mains which extend over the entire terminal.

A steam main is laid from the boilers in the power plant of the 1,000,000-bushel elevator to the pumping station, and in the event the boilers of the latter are thrown out of service steam from that power plant will be available. The two fire pumps in the power plants of each of the elevators are also connected with the distribution mains. The combined capacity of the pumping equipment available for fire protection is thus about 12,000 gal. of water a minute. The pumps being supplied with six separate suctions in three entirely distinct sets the possibility of all these suctions being out of commission at the same time is very remote.

The system of distribution water mains extending from the pumping station to various parts of the terminal has been laid in such a manner that if one section of it is disabled that section can be cut out of the system without disabling the remainder of the system. A 12-in. main extends the length of the terminal on the land side of the two fireproof freight warehouses. An 8-in. main is also laid the length of the terminal on the land side of the wharf between the latter and the two freight warehouses. These two mains are cross-connected at various places. Gates are provided on these cross-connections so the section of either main between two connections may be cut out of service without interfering with the remainder of the system. A second 8-in. main extends from the pumping station along the land side of the freight warehouses close to the 12-in. main. Four 8-in. branches extend from the 8 and 12-in. mains along the warehouses to the cotton warehouse. These branches are placed at intervals of 600 to 1,000 ft. and cross the car storage yards of the terminal, which yards lie between the elevators and the warehouses. The pumps in the pumping station are separately connected with the 12-in. and the two 8-in. mains. The pumps in both elevator power houses are also separately connected with the 8-in. and 12-in. mains along the rear of the freight warehouses.

Each of the buildings of the terminal is provided with a distinct system of piping for fire protection. A 4-in. branch and riser from the 8-in. main along the rear of the wharf is placed at every 100 ft. along the rear of the wharf. A reel of hose is placed on a rack at each of these risers. A hose reel on a cart is also provided for incipient fires. The two freight houses both have two 6-in. water pipes extending the length of the building. One of these pipes is on each side of the building and is suspended from the wall. The pipes in both houses are connected at each end of the building with the distribution mains. The pipes in each section of each of the two buildings may be cut out of service without interrupting the supply in the remainder of the section. Four hose connections and four hose reels are provided in each section of the building.



Details of Roof Construction.

The two elevators are both equipped throughout with automatic sprinkler systems, which are normally under pressure from wooden storage tanks on the roof. These systems may also be supplied directly by the pumps of the particular elevator power house or from the distribution mains. The tanks on the roof have the same sources of supply. Each section of the cotton warehouse has a 6-in. connection with an 8-in. main, which extends the length of and parallel to the warehouse, joining the four 8-in. branches across the car storage yards. Risers are provided in the warehouse from these 6-in. connections and a 6-in. pipe is extended across each section of the building, suspended from the roof columns. A 6-in. branch is extended, on both sides of the sections from each of these risers. Four hose connections and hose reels are provided in each section of the building. The 6-in. connections with the 8-in. main are each provided with gate so the supply for each section is entirely independent of that for any other section, and the loops formed by the four 8-in. branches provide additional independence of the supply.

Seven Niagara fire hydrant towers are located at various points of advantage around the terminal for fighting fires among the cars in the terminal yards and for attacking fires from the outside in the buildings. These towers have platforms mounted about 15 ft. above the ground on a heavy iron column and are each fitted with 2½-in. nozzle mounted on a standard in much the same way that the nozzle is mounted on the water towers used in various city fire departments. These nozzles may be deflected in any direction and are controlled by an operator on the platform. The platform is surrounded with galvanized sheet iron for the protection of the operator, and may be kept cool by water from a perforated pipe around the top of the inclosure. These towers are said to throw a 2½-in. effective stream a distance of 240 ft.

A complete fire alarm system is also provided in the terminal. The receiving and recording apparatus of this system is located in the pumping station, where employes are always on duty. Fire alarm boxes are placed at convenient points around the terminal and are connected with the receiving apparatus. A regular fire marshal and a force of watchmen are always on duty. Fire alarm drills are practiced regularly by this force and the fire protection system is frequently inspected.

The terminal was planned and has been built under the direction of the engineering department of the Illinois Central R. R., Mr. A. S. Baldwin, chief engineer. Mr. R. E. Gaut, as engineer of bridges for that department, has had personal supervision of the design and construction of the various buildings. The construction work was carried on under the immediate direction of Mr. W. S. Greenfield, assistant engineer. The wharf and the two fireproof freight houses were built by James Stewart & Co., under the direction of Mr. W. H. Lohmann, western manager, and under the immediate supervision of Mr. John H. Frederickson, representative of that company at New Orleans. The two elevators and the cotton warehouse were built by the George B. Swift Co., of Chicago; Mr. George F. Jenkins, vice-president of that company, directed the work on these structures.

Motor-Driven Compressors for Sewage Pumps.

Motor-Driven Pumps for Refrigerating Plant.

The Hama-Aleppo Ry., in Syria will be opened on Sept. 1 with special ceremonies, as that date is the anniversary of the accession of the Sultan.

The Central Power Plant of the Oliver Estate, Pittsburg, Pa.

The central power plant of the Estate of Henry W. Oliver, Pittsburg, Pa., is interesting as an example of an installation in the heart of a city's business center to furnish light, heat and power to several large office buildings and churches, the McCreery department store, Duquesne Club and a number of smaller consumers. It has 1,459 kw. wired in load, which, with contemplated extensions in the near future, will ultimately increase to approximately 3,000 kw.

The Westinghouse three-wire, direct-current system of distribution is used, with an electromotive force of 220 volts between outside mains. In comparing the three-wire and two-wire systems, the engineers found that, for a given drop in potential when the voltage between outer wires and the neutral is equal to that of a two-wire system and the neutral wire was the same size as the outer wires, a saving of 62½ per cent. in copper was obtained, which gave an economical distributing system for a plant supplying a considerable area with light and power. In the earlier installations of the three-wire systems it was necessary to use two separate generators in series, with the neutral wire joined to the common connection, which necessitated the operation of both machines regardless of the load carried. A later development was the use of a balancing set in connection with one generator. This had some advantages over the older method, but was not all that could be desired. The Westinghouse three-wire system was designed to obtain all the advantages of such distribution without the necessity of using two separate machines or a balancing set, and to gain the additional efficiency of one large machine over two smaller ones.

Babcock & Wilcox boilers with a total capacity of 2,000 h.-p. are used. These are divided into four batteries of 500 h.-p. each, operating at a pressure of 150 lb. Each boiler is provided with chain grates manufactured by the Green Engineering Co., of Chicago. The coal is elevated from the storage bins to a traveling hopper by a conveyor, and scales in the cage beside the hopper provide a means for weighing all coal used. Both the conveying apparatus and traveling hopper are operated by electric motors and are easily and quickly handled. The hopper travels on an elevated track the length of the boiler room and is controlled from the floor by the fireman.

The generating units consist of three 200-kw. Westinghouse 220-volt, direct-current, three-wire generators direct connected to three Ball vertical twin-compound engines of 325 h.-p. each, operating at an approximate speed of 190 r.p.m., and one Westinghouse 375-kw. generator of the same type connected to a Ball Corliss-type vertical cross-compound engine of 600 h.-p., operating at 130 r.p.m.

Current is transmitted by lead covered cables to the switchboard, which is of the standard Westinghouse three-wire type with panels of white marble. As the series field coils of the generators are divided in halves, one half being on each side of the circuit, the protective devices and measuring instruments receive special consideration.

Circuit breakers are provided with special equalizer contacts to insure the opening of all circuits in case of excessive loads or short circuits. Two ammeters are used with each generator so that the load on both sides of the system may be observed. They are connected to the machines by special shunts mounted directly on the contact blocks and interposed between the series coils and armature, one on the positive and one on the negative side. A double-reading ammeter is connected in the neutral of each machine to show the amount of unbalanced load. A voltmeter connected across the main bus bars indicates the potential at all times and a second voltmeter, arranged to be connected to each motor by four-point voltmeter receptacles, enables the operator to adjust the voltage for paralleling. Two double-pole generator switches, two double-pole balance-coil switches and a shunt field rheostat complete the equipment of each generator panel. The balance coils are on a shelf near one end of the switchboard. Feeder panels are provided with instruments similar to the generator panels, with the exception of the field rheostat and balance-coil switches. A load panel is provided for measuring the total output of the station, upon which is mounted a Bristol recording voltmeter, two recording ammeters of the same make, and a switchboard type integrating wattmeter.

A daily record is kept of the readings of the various instruments on specially prepared blanks with spaces for hourly readings of the voltage and current. At the bottom of each sheet spaces are provided for the total of the hourly readings, average amperes per hour, readings of wattmeters and total watt-hours, furnishing valuable records which enable the efficiency of the employes to be checked and an estimate to be made of the fuel and supplies necessary at any season of the year.

The distribution system is extensive, owing to the large area supplied with power. A tunnel extends from the power plant to the McCreery and new Smithfield St. buildings for cables, steam and fire lines, refrigerating and cold water pipes. The balance of the consumers are supplied with cables run in underground conduits. The McCreery building uses a total of 775 kw., supplying 27 electric motors ranging from ½ to 50 h.-p., 486 arc lamps, 928 16-c.-p. and 600 8-c-p. incandescent lamps. The feeders for supplying current for this load are composed of 2,370 ft. of 1,600,000-c.-m., lead-covered cable, 2,340 ft. of 1,400,000-c.-m. lead-covered cable, and 7,941 ft. of 1,000,000-c.-m., paper-insulated cable, all manufactured by the Standard Underground Cable Co. The Smithfield and Wood St. properties are supplied by 4,620 ft. of 1,000,000-c.-m., lead-covered cable, each leg being approximately 250 ft. long, for supplying the balance of the consumers.

View of Cables and Piping in Tunnel.

The refrigerating apparatus for furnishing refrigeration to the McCreery store kitchen and drinking water for the building is located in the rear of the switchboard in the power plant. It is the absorption system, manufactured by the Carbondale Machine Co. In connection with the refrigerating plant, there are two Deane triplex water pumps, two brine pumps made by the same company, and three ammonia pumps, all of which are driven by means of Morse silent chain by Westinghouse motors ranging in size from 3½ to 15 h.-p.

Exhaust steam from the engines is utilized to evaporate the ammonia, which is in the form of a 26 per cent. solution. The steam circulates in pipes through the solution, causing the free ammonia to pass upward through a series of perforated baffle plates for draining off moisture; after passing through coils for further draining, it is carried into a cylinder containing coils of pipe through which the brine circulates, the ammonia absorbing the heat from it. The brine is then pumped to the McCreery building through two 2½-in. iron pipes, one for supply and one for return. A 2½-in. brass pipe furnishes the drinking water.

In addition to the refrigerating pipes leading to the McCreery building, there is a 2-in., a 3-in. and a 1½-in. line for high-pressure steam to supply the kitchen for cooking purposes; one 8-in. main with 4-in. return and one 4-in. main with 2-in return for heating purposes; an 8-in. fire line under 150 lb. pressure; and a 10-in., a 7-in., a 4-in. and a 1½-in. high-pressure line for high-pressure elevators. There is a total of 24 elevators, 18 hydraulic and 6 electric, which utilize power taken from the central plant.

There are several interesting motor applications in the McCreery Building, among which may be mentioned a 30-h.-p. constant-speed Westinghouse motor operating a cold-air fan for ventilating purposes; two 8-h.-p. Westinghouse, 220-volt motors operating elevator safety devices, and a 25-h.-p., Westinghouse, constant-speed motor driving the apparatus used in raising the building sewage to the level of the street mains.

The Largest Building Contract ever placed in New York City is stated to be that recently awarded to the George A. Fuller Co. by the Pennsylvania R. R. Co. for its terminal structure recently described in this journal. It is expected that the contract will run over $15,000,000.

Technical Photography.

There can be no question about the value of the camera as a means of recording the progress of construction. The apparatus used is comparatively inexpensive, unless an attempt is made to secure the highest grade of views, which are unnecessarily costly for engineering purposes. The greatest obstacle to the extension of amateur technical photography is the lack of available information concerning its general features. On this account the following notes on the subject have been taken from an interesting lecture recently given by Mr. Frederick Henius of Pittsburg before the Engineers' Society of Western Pennsylvania. The full text will be found in the Society's "Proceedings" for May.

The camera should be rigid, and strength should not be sacrificed for weight. It should be provided with long bellows, which should be parallel on the top and bottom, and only taper slightly on the sides. It should also have a rising-front which when raised should not take the bellows along, and should be provided with extreme double swing.

For landscape and art photography a very fine lens is not necessary, as you work for effect and not for detail. In portrait work a portrait lens is absolutely necessary; for commercial work an "anastigmat" lens only should be used. Astigmatism is a defect inherent to all the older forms of lenses, and has been approximately eliminated only during recent years in the anastigmatic lenses made possible by the new kinds of optical glass. Astigmatism means "without a point," and as used with reference to the lens, may be defined as the inability of a lens to bring vertical and horizontal lines (such as the plus sign boldly printed on a white card) to a focus at the same time, although both lines lie in the same plane. Its elimination enables us to secure sharper definition over the whole of the picture-image, a greater angle, and consequently a greater intensity, with flatness of field and covering power. It is without doubt the only lens to use for machinery, interiors and copying.

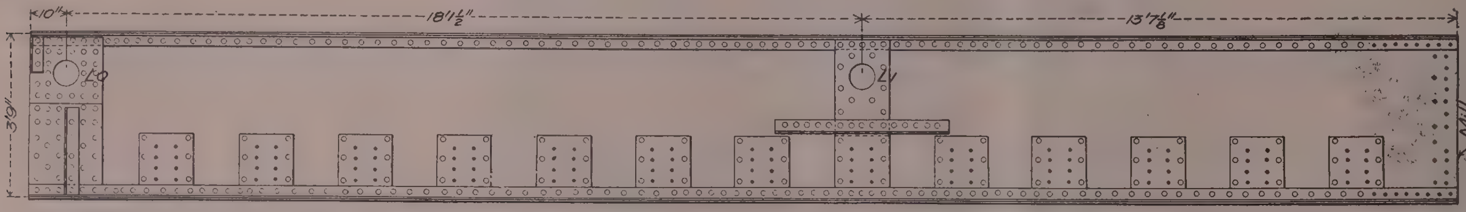
The focal length or focus is the distance from ground glass to diaphragm, when a subject 100 ft. or more away from the camera appears sharp on the ground glass. The aperture is the diameter of the working part of the lens when fully opened. The depth of focus is the property possessed by a lens of giving an equally sharp image of objects situated at various distances from the camera. Correctly speaking, however, depth of focus is not a property peculiar to any particular form of lens, but to a combination of lenses. A lens working at full aperture, without being stopped down, will hardly produce sharp objects when the subjects are at a distance from the camera. By stopping down, however, considerably more depth is secured, but the illumination is sacrificed and consequently the rapidity.

Of two lenses of the same intensity (rapidity) but differing focal length, the lens of shorter focus will give the greater depth of definition. Of two lenses of identical focal length, but one having greater intensity (rapidity) than the other, the more rapid lens will apparently have less depth of focus, but when this lens is stopped down by the use of a diaphragm to the same rapidity as the slower lens, the two lenses will have the same depth of focus. In other words, depth of focus with any given stop, is an invariable quality in different lenses of the same focal length, regardless of their construction.

The diaphragm or stop plays quite an important part in the use of lenses. It consists of a piece of blackened metal, with a circular aperture at the center, which is placed before the lens if it is a single lens, and between the two elements if it is a doublet. An Iris diaphragm consists of several segments of a circle of metal or vulcanite, working on pivots attached to a ring in the lens mount. By rotating the ring, the circular aperture formed by the segments may be made smaller or larger at will. The diaphragm evens the illumination of the plate, and increases the defining power of the lens over a larger area and gives greater depth. The volume of light that passes through the diaphragm is proportionate to the area of the aperture, and the areas of circles are proportionate to the squares of the diameters.

We have various makes of diaphragms which have been adopted by the various makers, but the most popular ones are the F stops and the U. S. stops. For commercial work, a lens working at an aperture of F 6.8 is fast enough for instantaneous work. It will do in almost any condition in photographing any quick-moving subject where the exposure will have to be the one-thousandth part of a second, or even less. With a larger aperture, however, the lens has less depth, and if you have to stop down in order to get depth you are not gaining anything by using such a lens. Portrait lenses are only used with full opening, as depth is not essential—only speed. Single combinations, even such as we find in using the front or rear of the "anastigmat" lens, should not be used for machinery or interiors, as they will show curvature.

The tripod should be strong and rigid, so that the camera will be on a solid base, as the least vibration, which often exists in machine shops or when taking exteriors on a windy day, would spoil the picture. A level is absolutely necessary in photographing machinery and buildings, as the ground glass must be parallel to the subject in order to obtain straight and parallel lines. This is especially the case in photographing buildings. It is quite important in photographing machinery that we get a good perspective, and this can only be obtained if sufficient distance from the machine to the camera can be had. Perspective does not depend upon the lens used, but is governed entirely by the distance from the subject to the lens, and nothing else. If we get too close to the machine we will find that the parts nearest the camera are too large compared with the parts farthest away, and we get a machine which looks distorted.



Elevation of Stringer, Bridge No. 1, Mahoning Division, Erie R. R.

Illumination is another important factor. Most machines are too large to move around, and you will have to take them under the conditions which exist in the shop. But where the machine can be moved, the light should, if possible, come from the upper left-hand corner, illuminating the front and the side of the machine where a three-quarter view is desirable. The front and side should not be illuminated exactly alike, as we kill the contrast.

Photographing buildings is quite a difficult task, as most of them are quite high and the distance limited. In such cases an extremely wide angle lens will have to be employed, and the perspective will not be right. Interiors usually have to be taken by the light existing, but in many cases flash light will have to be used. This is especially the case with interiors of power plants, which are frequently installed in the basement of large office buildings. You have noticed, in many exteriors and interiors, that a certain amount of halation appears on the photographs. This is caused by the light passing through the film and striking the glass. A double coated plate should always be used for such purposes, as they do away with the halation to a certain extent. An interior where lots of windows are included should never be taken against the source of light. The source of light should always be behind your camera. In photographing machinery, a large background should be secured in order to get distinct outlines of all details. It is also necessary to lay quite a lot of white paper around the bottom of the machine, separating the base of the machine from the floor of the shop, as it is otherwise quite difficult to get the outline. The bright parts of the machine should appear bright, and should not be painted with any color. The rough parts, of course, should be painted with a smooth gray flat color.

In making the exposure of a machine, we must consider the height of the camera from the floor. In many cases, say for a small machine, we might get up too high and would get a very bad perspective, while in photographing larger machines it is necessary to put the camera up on a platform. The exposures should be liberal. A correctly exposed plate is very seldom found, but when we are using a double coated plate we have considerable leeway in developing, and we can give our pictures full time.

It is quite an important factor to know how to develop, as any plate of a machine may be ruined or saved by improper or proper developing. It is almost impossible to develop a plate of a machine or an interior by submerging it in the developer. Local developing should be adhered to, and the plate should be developed very slowly, so that the progress can be watched. The double coated plates are more difficult to develop than the single coated, but nevertheless they are the only plates to use. A clearing and hardening bath should be used, especially in summer, so as to prevent the plates from frilling and in order to obtain clear plates. Always use the same developer on the same plate, as the same developer does not work the same on two various brands of plates, and two developers do not work alike on one brand of plates.

You must develop in a diluted developer and use local developing. Take a developer which would develop a plate in ten minutes, dilute it ten times, and you have one hundred minutes. Dilute it sufficiently to take seven or eight hours to develop a plate, insert your plates in the tank, and the next morning they are all developed. They use this tank system a great deal in England. Develop a plate slowly and you have a chance to rectify any fault. When the image comes out put the plate in water and let it stand awhile. Look at it occasionally, put it in the developer again till you have got all the details out; after that is done put the final strength to it.

A very good developer for under-exposed plates is amidol. Amidol is good for all kinds of snap shots, which are under-exposed plates. Sometimes you have to photograph a white building against a blue sky. The white building and the sky appear absolutely white on the plate. The way to avoid that would be to use an isochromatic plate so as to get the values of the blues.

In order to restrain the high lights, while you bring out the detail in the shadows, develop the plate until the high lights appear, then lay it in water, leaving it there a little while. Use a two-solution developer, which should be mixed according to results wanted. If you should get too strong high lights you can reduce them with ammonia persulphate 1 to 10. Stop it afterwards with a 10 per cent. solution of sulphite of soda. Ammonia persulphate reduces the plate in the same proportion as you develop it; the high lights that came out first are reduced first.

With isochromatic plates you have to work at a considerable distance from the light. You should cover up the plate instantly when you start it. I use ruby light and yellow light and tissue paper in between.

For isochromatic plates I use two trays. I do not use isochromatic plates except in copying colored pictures or oil paintings, and do not see much use for them if you are only going to use the photograph for cuts. When you take a photograph of a valuable oil painting, one of the old masters, you must use them, as such copies are used for framing and must possess all of the values contained in the original. A ray filter might or might not help. They are very good for oil paintings, flowers and water colors, but when it comes to rectify values for one color they destroy them for another.

When you take a picture of a high building you raise the front as much as you can and tilt the camera, then you apply the level to the ground glass; you must not tilt the ground glass any farther than your level permits. The moment your swing back is pulled out as far as it will go and remain level, your limit is reached, and you must remember that by tilting it you are losing depth. The best way is first to raise the front as far as the light circle permits; if you still cannot get the picture, tilt the camera. You might rectify a distorted photo in copying by tilting it.

In printing, various papers can of course be employed. For half-tone reproduction, solio paper should be used, and the prints should be ferrotyped, so as to minimize the grain of the paper, as it generally shows in half-tone reproductions. For scenery and art work, platinum paper is the only paper to use. It gives a very artistic effect, but of course some detail is sacrificed, as the paper has a rough surface; but in art work we only consider effect, and not details.

THE QUALITY OF PRODUCER GASES was discussed in a paper read by Mr. A. Witz before the Mining Congress at Liege, in which he claims a producer efficiency of 82.2 per cent. with Welch anthracite, 73.8 per cent. with coke and 62.8 per cent. In general, he believes that the efficiency falls when the weight of steam introduced equals that of the coke. In some trials the quantity of gas produced seemed to diminish with the quantity of steam and air admitted, although its calorific power increased. While working cold results in the deposit of tar in the flues, it saves the grate and walls and prevents the formation of pasty slag. With steam the deposit is sooty and friable ash is produced, with more wear.

An All-Steel Open-Floor Railroad Bridge.

Two tracks of the Erie Railroad cross over four tracks of the Big Four system at a considerable angle on a through truss bridge of 163 ft. 1½ in. span at Cleveland, Ohio. The bridge is officially designated as No. 1, Mahoning division, and has three pin-connected trusses supported on abutments, one of which is skewed about 1:1.192 and the other 1:1.169. The panel points of the trusses are all in the same transverse line, the north truss extending one full panel point beyond the middle truss, and the middle truss extending one panel point beyond the west truss at the west end. At the east end, the end panel of each truss is special. The trusses are of the Pratt type, 36 ft. deep and 15½ ft. apart on centers, with a clearance of 32 ft. above the base of rail and 13 ft. 4 in. between trusses.

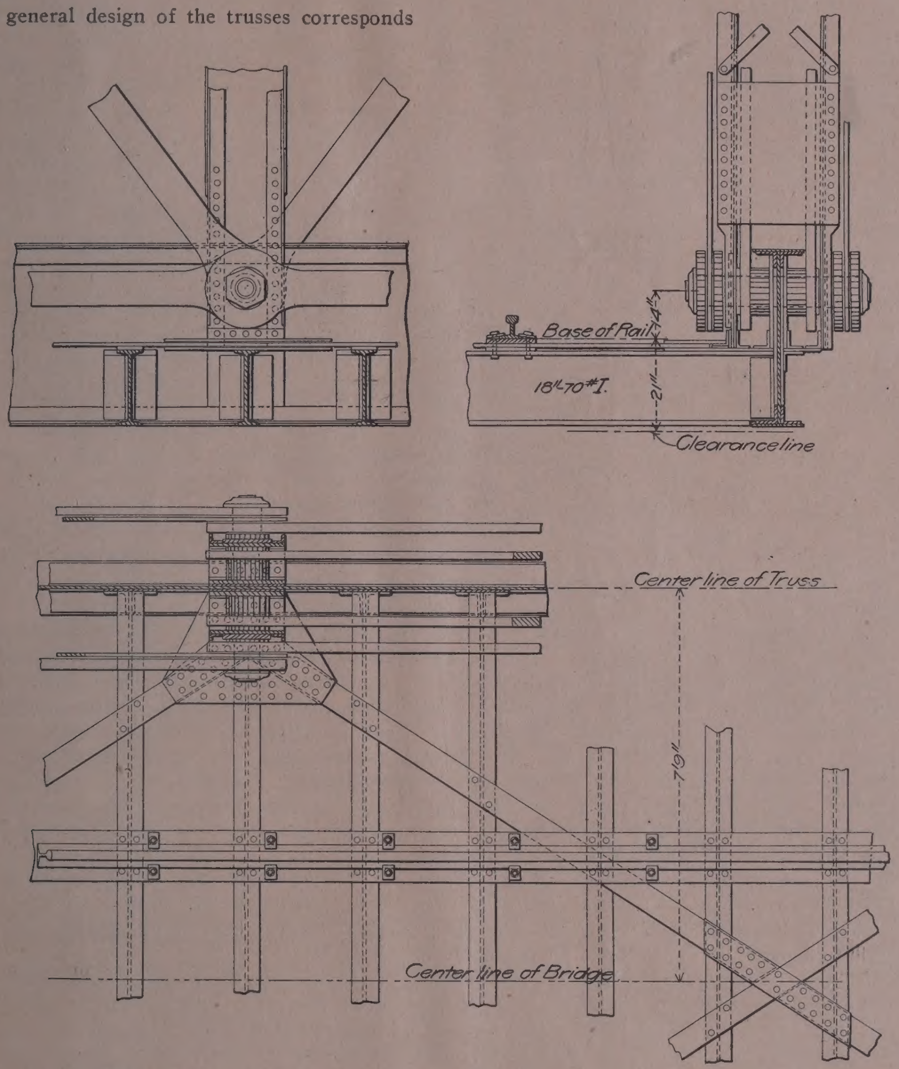
The general design of the trusses corresponds to ordinary standards except that the vertical posts are field-riveted to gusset plates which are shop-riveted to the top chords. All of the main truss connections are pin-connected, and splices are made in the top chords at points U_2 at the west end of the bridge to allow for the separation of the trusses here in case it should be necessary in the future to extend the span a few feet beyond the present abutment. This provision was made because the railroad company found it impossible to secure title to the site of the abutment and wished to be prepared for a modification of the structure in case it should be necessary in the future to remove the existing abutment and build a new one adjacent to it. In this event the ends of the trusses will be separated as noted, an additional panel will be inserted, and the original end panels joined to them, completing the extended truss. The present truss has been designed with provision for the additional stress which will be developed by such an extension.

The most interesting feature of the bridge is the special floor, which was designed to combine solid steel construction with the least possible obstruction to the smoke and gases from the locomotives on the tracks under the bridge. The rails are carried directly on heavy longitudinal plates riveted across the top flanges of transverse 20-in. I-beams 38 in. apart on centers. These floor-beams are web-connected to plate-girder stringers supported directly by the lower-chord pins, as indicated in the accompanying detail. The stringers are made in two-panel lengths connected together by ordinary field-riveted double-web splice plates, and are bored to receive the lower-chord pins just below the top flanges, where the webs are reinforced to a total thickness of about 2 in. Each stringer is made of a 44¾x7/16-in. web, two 5x3½x⅜-in. full-length angles and one 12x⅜-in. full-length cover plate in each flange. A ⅜-in. plate is shop-riveted to the web to reinforce it for the connection with each floorbeam which is made with eight ⅞-in. rivets. The lower lateral bracing consists of flat plates riveted to the top flanges of the floorbeams and to horizontal gusset plates field-riveted to the vertical posts below the chord pins.

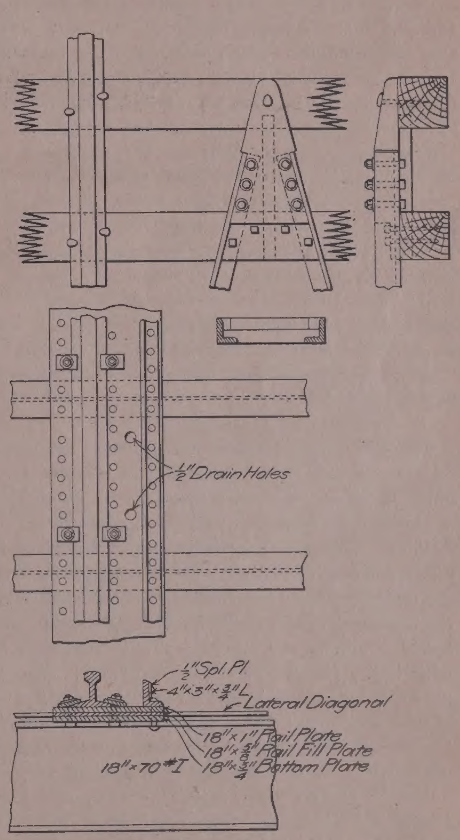
Each rail is supported on a compound longitudinal plate 18 in. wide and 2⅜ in. thick, which has ample stiffness to pass across the spaces between the floorbeams. This plate is made in three thicknesses, the lower one being a continuous 18x¾-in. plate crossed at intervals by the ⅝-in. lateral diagonal bars between which there are continuous 18x⅝-in. fillers. On top of these there is an 18x1-in. plate which receives the rail and a 4x3x¾-in. guard angle field riveted to it and to the floor beams. The rails are secured by steel clips and bolts, and the plates are riveted together and to each other by three longitudinal lines of ¾-in. field rivets pitched about 4 in. The guard angles are so heavy that it is believed they will confine the wheels to the track plates in case of a derailment on the bridge. They are extended about 35 ft. beyond the ends of the truss and their converging ends are connected by heavy plates and castings to form solid points intended to engage and restore the wheels to alignment if they should be derailed at the approaches. In the end panels, the floorbeams are connected at one end to the stringer and at the other end have oblique web-connection plates field-riveted to an end transverse girder parallel with the abutment face. The track plates extend about 4 ft. beyond these girders and are supported on the wooden ties to which they are bolted, the bolt holes being slotted in the expansion ends of the bridge to provide for temperature movements. The total weight of the bridge is 941,355 lb.

The special construction above described was adopted on account of the fact that the overhead tracks were for very heavy slow trains to the ore docks. The open floor was designed to prevent the smoke from hanging under the bridge, and the conditions make it improbable that a derailment will occur on the bridge.

The bridge was designed and constructed under the direction of the engineering department of the Erie Railroad, while Mr. C. W. Buchholz was chief engineer, Mr. Mason R. Strong, engineer of bridges and buildings. The steel work was manufactured by the King Bridge Co., Cleveland, Ohio, and was erected by the railroad company.



Floor Construction and Connection of Stringers to Lower Chord Pins.



Track Plate and Guard Rail.

Book Notes.

Two of the "red books" recently issued by the British Fire Prevention Committee contain reports of tests of fire-resisting construction originally developed in this country. The first describes experiments with a concrete floor of three bays, all reinforced by expanded metal, but differing in detail. This floor formed the roof of a testing station and was plastered below. It was loaded to 224 lb. per sq. ft. and then subjected to the usual fire tests of the committee, which were passed successfully. The second report describes tests of Kinnear rolling shutter doors, which were passed successfully. The reports are fully illustrated. That on the floor is sold at 2s. 6d. and the other at 3s. 6d. at the office of the committee, 1 Waterloo Place, London.

The last bulletin issued by the Association of American Portland Cement Manufacturers contains an elaborately illustrated article by Frank B. Gilbreth on the making and driving of corrugated concrete piles. This is an interesting account of the causes which led to making the piles in the first place, an explanation of their advantages, and a description of the installations in which they have been used. The bulletin can be obtained without charge on application to the association's office, 1232 Land Title Building, Philadelphia. It might be added that other valuable bulletins can also be obtained from the same source, their titles being: "Concrete Building Blocks," by S. B. Newberry; "The Possibilities of Concrete Construction from the Standpoint of Utility and Art," by Wm. L. Price; "Sand for Mortar and Concrete," by Sanford E. Thompson; "Notes on Cement Testing," by W. P. Taylor; "Irregular Methods of Testing Cement," by H. A. Schaffer; "Comment on the Advantages and Limitations of Reinforced Concrete," by Charles S. Hill; "The Proportions of Cement Mixtures," by Spencer B. Newberry; "Methods of Testing and Some Peculiarities of Cement," by W. A. Aiken; "The Decoration of Concrete with Colored Clays," by Henry C. Mercer.

The River and Harbor Act of 1902 appropriated $200,000 for an investigation of a 14-ft. navigable waterway from Lockport to St. Louis, and a similar waterway 7 and 8 ft. deep from La Salle to Ottawa. The Mississippi River Commission was charged with the investigations from the mouth of the Illinois River to St. Louis, while the remainder of the work was in charge of a board of officers of the Corps of Engineers, of which Col. O. H. Ernst was chairman. The report of this investigation has been issued as House document 263, first session, fifty-ninth Congress, and contains a great deal of valuable information concerning the engineering features of the proposed barge canal between the Great Lakes and St. Louis. The route adopted will require the canalization of the Illinois River by nine locks and five movable dams from Lockport, where it connects with the Chicago Drainage Canal, to Utica. From Utica to Grafton four existing dams will be taken out and the channel dredged. This work is estimated to cost about $23,500,000, using concrete locks 600 ft. long, 80 ft. wide and 14 ft. deep on the sills. The cost of the 7-ft. and 8-ft. waterway from La Salle to Ottawa is estimated at $928,000 and $961,000, using locks 350 ft. long and 75 ft. wide. The Mississippi River improvements include a movable dam at Alton, a lateral canal from Alton to St. Louis Harbor, and a lock 600 ft. long, 80 ft. wide and 30 ft. in lift. These works are estimated at $6,554,000. No opinion concerning the advisability of undertaking the project is expressed in the report, as it is not called for in the act ordering the survey.

The records in the Cameron septic tank litigation are about to be printed by the Village of Saratoga Springs, the principal defendant. The testimony so far as put in comprises the record of the plaintiff's case in chief, which is but a brief appearance, entering in evidence the patent in suit, and certain evidence as to the defendant's alleged infringement in the Saratoga plant, constructed under the supervision of Messrs. Snow & Barber, engineers, of Boston. The defendant's rebuttal testimony comprises an exhaustive history of the art of sewage purification, by Mr. F. Herbert Snow, with special reference to the use of settling and separating tanks, English and American patents, citations from the history of the art, showing the intentional use of decomposition, a review of the work of Louis Mouras in France; Dr. Alexander Mueller, of Berlin; Prof. Pagliani, in Italy, and Waring, Philbrick and others in America. Mr. Snow was followed by Prof. A. N. Talbot, of Champaign, Ill., giving the history of his inception of the Champaign and Urbana tanks, built in 1894, their construction and operation. He was followed by Mr. W. S. MacHarg, consulting engineer of the Sewer Department of Chicago, who testified as to the intentional use of septic tank, and facts in the construction of early tanks at St. Joseph's Hospital and Altenheim, near Chicago, with citations from early published descriptions of same. Mr. Henry W. Hill, an architect of Chicago, also put on record facts of the early construction of an intentional septic tank at St. Bede's College, Peru, Ill. Mr. Benezette Williams, of Chicago, followed with testimony relating to his association with Col. Waring in the Flush Tank Co. and their development and use of house tanks. Liberal citations were made from catalogues published by the Flush Tank Co. and quotations from the early writing of Colonel Waring, showing his intentional use of decomposition for the disposal of house wastes. The final witness for the defense was Mr. John W. Alvord, of Chicago, who reviewed the history of the art in corroboration of Mr. Snow, calling special attention to prior uses which had been brought out in the testimony as to facts, as well as a review of the American and foreign patents of intentional prior uses, and testimony relating to the construing of the patent in suit. The plaintiffs introduced as experts Prof. William Main, of New York City, and Mr. Herbert Wylie, their general superintendent. Their testimony tended to show that the prior use tanks, cited by the defendants, were either not true septic tanks in the sense intended by the patent, or were not intentional septic tanks in any sense. A careful review of the subject of bacterial purification and decomposition was made by Prof. Main, in the light of which the prior uses were construed. Mr. Wylie's testimony corroborated that of Prof. Main, covering practically much of the same ground in a perhaps somewhat more brief and general way. The record comprises a careful review of the subject of sewage purification in the latter half of the 19th century, with an exceedingly thorough and exhaustive collection of patents, citations and drawings bearing on the subject of the art of using tanks in sewage purification, forming a digest probably more complete than has ever been put together before upon this subject. In order that those who are specially interested in the matter might be afforded an opportunity to obtain a copy of defendant's record, it has been proposed that a limited number of copies might be made available for purchase, if applications are filed in advance; otherwise the printing of the edition will be limited to the immediate needs of the case. Applications for copies may be made to Mr. John J. Healey, of Saratoga Springs, N. Y., or Mr. John W. Alvord, C.E., Hartford Building, Chicago, Ill.

Biological Studies by the Pupils of William Thayer Sedgwick. Printed for private circulation. A few extra copies will be sold at $5 by Dr. Edwin O. Jordan, University of Chicago.

The book bearing the above title is a "festschrift" in commemoration of the twenty-fifth anniversary of the doctorate of William T. Sedgwick, professor of biology at the Massachusetts Institute of Technology, and identified with the work of the Massachusetts State Board of Health and American sanitary science in general. It is a collection of scientific papers by nineteen of his pupils. Some of the papers are of a purely biological character and have no special interest to engineers; others relate to water supply and general bacteriology and should be of much interest to sanitarians. These papers are the following: "Experimental Methods as Applied to Water and Sewage Works for Large Communities," by George W. Fuller; "The Futility of a Sanitary Water Analysis as a Test of Potability," by Marshall O. Leighton; "The Value of Pure Water," by George C. Whipple; "The Occurrence of Organisms of Sanitary Significance on Grains," by Samuel C. Prescott; "A Study of the Numbers of Bacteria Developments at Different Temperatures, and of the Ratios Between Such Numbers with Reference to Their Significance in the Interpretation of Water Analysis," by Stephen DeM. Gage; "The Toxic Effect of Certain Acids Upon Typhoid and Colon Bacilli in Relation to the Degree of Their Dissociation," by C. E. A. Winslow; "The Inhibiting Effect of Certain Organic Substances Upon the Germicidal Action of Copper Sulphate," by Earle B. Phelps, and "A New Solution for the Presumptive Test for Bacillus Coli," by Daniel D. Jackson.

The paper on experimental methods by George W. Fuller gives in compact form a summary of the work of the various experiment stations which have existed in this country since 1887, and which, taken together, have cost about two-thirds of a million dollars. Mr. Fuller states the following objects and advantages of experimental methods:

1. "To provide data for the official and technical authorities, to enable them to adapt new works most advantageously to the local conditions, and to indicate dimensions and other physical conditions permitting contract plans to be prepared and the cost of construction to be approximately estimated.

2. "To educate the non-technical public, who as citizens and taxpayers are interested in public works.

3. "To provide data so that the officials can operate effectively the works after they are completed, and forecast the approximate cost of operation."

He also described some of the leading experiment stations in Europe, most of which have related to sewage disposal rather than to questions pertaining to water supply. In the course of the article the author pays a high tribute to the work of Prof. Sedgwick. He says: "It is the belief of the writer that the work accomplished by Prof. Sedgwick along this line is unequalled by that of any other man in this country, either in educational or other lines, and that this fact in a few years will be far more widely realized than at present, when his younger pupils throughout the country reach an age where their work will be felt in the communities in which they live. This influence is already to be found in many unexpected places, and forms a wonderful tribute to the success accomplished by Prof. Sedgwick in one of his many lines of usefulness."

In a paper on "The Futility of a Sanitary Water Analysis as a Test of Potability," Mr. Marshall O. Leighton takes issue with the old method of interpreting the chemical analysis of water, as set forth in a recent address of Prof. L. P. Kinnicutt. The author takes the radical ground that "the conventional method of seeking the evidence of pollution by sanitary analyses or of accepting or rejecting water upon such evidence is in its broad and essential features quite misleading, too frequently dishonest, and in some cases absurd. The dangerous pollution of surface waters can be discovered more readily, and at far less risk and expense, than by sanitary analysis." He gives many illustrations to show that the old method of interpreting the quality of water from the nitrogen determinations, etc., is incorrect, and in this respect most modern water analysts would agree with him. The chief objection to be brought against Mr. Leighton's paper is its title. From it one would gather the idea that a sanitary water analysis is worthless. Reading the paper, however, one finds that the author's criticisms are directed only to certain chemical determinations which for some time past have been looked upon askance from the standpoint of interpretation by many water analysts, although most of them are still made as a matter of routine or for the sake of comparing present data with those obtained years ago.

The paper on "The Value of Pure Water," by George C. Whipple, is a general discussion from the financial standpoint of the value of water to the consumer. The qualities considered are the sanitary quality, general attractiveness, hardness and temperature. The attempt is made in each case to express these characteristics in terms of dollars and cents to the consumer in order that waters different in character may be judged upon some common ground. The following is a summary of the points considered:

1. Pure water as compared with impure water has a real financial value to a community.

2. This value may be measured by determining what impure water costs the community.

3. There are three principal characteristics which affect the value of water to the general consumer—its sanitary quality, its general attractiveness and its hardness.

4. A formula is suggested for computing the effect of the sanitary quality of water on its financial value to a community. It is based on the typhoid fever death rate.

5. A formula is suggested for computing the effect of the general attractiveness of water on its value to consumers. It is based on the physical characteristics of turbidity, color and odor.

6. A formula is suggested for computing the effect of the hardness of water on its value to the consumers. It is based on the use of soap in the household.

7. Considered from the financial aspect alone, and disregarding all humanitarian considerations, the filtration of a polluted water supply adds very greatly to the vital assets of a community; hence, as a mere business proposition, no city can afford to allow an impure water supply to be publicly distributed.

8. The advantages to a community of having a water supply, not only safe, but also attractive in appearance, taste and odor, are material from a financial aspect. The increased value of many waters because of the improvement in their æsthetic qualities alone justifies the cost of filtration.

9. Water softening at present does not receive the attention it deserves at the hands of municipal authorities. The economic advantages to be gained by removing the hardness of water are so great that, in many cases, the saving to the ordinary water consumers justifies the cost of softening water.

10. The formulæ here suggested and the detailed results derived from their use are not to be considered as of great accuracy, as the assumed data are not fully adequate. They are given merely to show the possibility of computing the value of pure water in terms of dollars and cents, and to illustrate the financial value of filtration and justify its cost.

In the course of the paper data are given showing the effect of filtration in reducing death rates from typhoid fever and other diseases and in increasing the value of the water filtered by improving its physical character. An attempt is made to combine the qualities of odor, color and turbidity in such a way as to obtain a single value to represent the general attractiveness of water. Numerous applications of the formulæ are given, but the author states that they are to be taken as merely illustrative.

Professor Prescott's paper on "The Occurrence of Organisms of Sanitary Significance on Grains" is a bacteriological study of certain organisms resembling B. coli isolated from the heads of grain under conditions such as to preclude contamination with fœcal matter. The author was unable to detect differences between these organisms and typical forms of B. coli obtained from the human intestines. As a result of his studies he concludes that B. coli is more widely distributed in nature than has usually been thought to be the case, a fact which has a very important bearing upon the interpretation of bacteriological results as now conducted in the ordinary water works laboratory. He states that "as a result of careful study, we are not inclined to believe that our results invalidate the bacteriological examination of waters for the Eastern States at least, except in the immediate neighborhood of grist mills, etc.; but they certainly render it imperative that great care should always be used in the interpretation of results. Certainly the old and fast rule concerning the significance of the presence of any 'intestinal forms' as prima facie evidence of sewage pollution must be most discriminately applied."

The paper by Stephen DeM. Gage on "A Study of the Numbers of Bacteria Developing at Different Temperatures and of the Ratios Between Such Numbers with Reference to Their Significance in the Interpretation of Water Analysis" is an attempt to increase the value of bacteriological determinations of water by adding an additional factor which can be used in interpreting results. The studies were made at the Lawrence Experiment Station, using well waters, sewages and waters intermediate in quality, covering a wide range of sources.

The paper on "A New Solution for the Presumptive Test for Bacillus Coli," by Daniel D. Jackson, of Mt. Prospect Laboratory, Brooklyn, is an interesting one. He shows how the ordinary presumptive test for B. coli often fails and suggests the use of a new solution which gives much better results. The method is a modification of what is known as MacConkey's bile salt method which has been so successfully used in England in recent years, but which has received up to this time too little attention in this country. Mr. Jackson shows how fresh ox bile, or Platiner's crystallized bile, may be used in place of the more expensive Sodium Taurocholate. As a result of his studies the author states the following conclusions:

"The bile salts, and especially their acids, exert a strong restraining action on most species of bacteria which grow at blood heat.

"This restraining action is selective. It favors the increase of B. coli, retards the growth of certain streptococci, and actually kills off the majority of species which grow at 37° C.

"The effect is due to the cholic acid radical and is, therefore, common to both of the bile salts.

"Advantage may be taken of the selective action of the bile salts in the determination of B. coli in water by planting various amounts of the water to be tested in bile lactose solution. The results are much more accurate than those obtained by the methods at present employed."

Messrs. C. E. A. Winslow and E. E. Lochridge have a paper on "The Toxic Effect of Certain Acids Upon Typhoid and Colon Bacilli in Relation to the Degree of Their Dissociation." The authors originally undertook to estimate the effect of acid sewage on the longevity of the typhoid bacillus, but the problem proved such a complicated one that they concentrated their attention on one phase of the subject. As a result of their researches they found that solutions of mineral acids, such as hydrochloric and sulphuric, are toxic in proportion to the amount of dissociated hydrogen, while in the case of organic acids, such as acetic and benzoic, the toxicity is due not so much to the hydrogen ions as to the undissociated molecules of the acid. They found that in the presence of organic matter, such as peptone, the toxicity of the acids was very much decreased. The typhoid bacillus was found to be much more easily killed than the colon bacillus. In their experiments they observed a fact which others have observed, namely, that while it may be comparatively easy to destroy 99 per cent. of the typhoid bacilli in any particular culture, it is more difficult to destroy the remaining one per cent. A few of the bacilli in every culture appear to be much more resistant than the rest.

The paper of Mr. Earle B. Phelps on "The Inhibiting Effect of Certain Organic Substances Upon the Germicidal Action of Copper Sulphate" is an important one, as it shows that the toxic effect of copper may be reduced to a considerable extent by the presence of organic substances. The author considers that this has a practical bearing in connection with the use of copper sulphate for disinfecting purposes. He believes that results obtained in the laboratory, using distilled water, are not in the least indicative of what may be expected under field conditions. Mr. Phelps found, just as Winslow and Lochridge had found, that a certain number of typhoid fever bacilli were able to withstand very large doses of copper. The author believes that most cases of typhoid fever contracted from drinking water have been due to these few resistant forms rather than to those which easily succumb under natural conditions. He states that "a removal of 99.99 per cent. of the typhoid fever organisms may sound like security, but actually it means high typhoid rates."

THE BURLINGTON RAILWAY is one of the most recent of the great transportation systems to organize an industrial department to assist in developing the cities and towns through which its lines pass. Although such departments are comparatively new they have already proved their importance in providing information to people contemplating establishing new or branch industries. In the past, when such departments did not exist, the task of determining the best location for a new enterprise was often an arduous one, but under the new conditions all that a manufacturer has to do when he contemplates entering a new field is to apply to the railways traversing it for such information as he considers necessary in aiding him to make a decision. The new department of the Burlington system, for example, which is under the direction of Mr. W. H. Manss, is gathering information concerning the economic conditions in the Mississippi valley, the sources of fuel and raw materials, the characteristics of every city and town and similar subjects. The data concerning the cities is particularly complete, embracing the population, assessed valuations, tax rate, banking, facilities, educational conditions, water works, sewerage systems, street railways, public lighting plants, raw materials fuel, labor market, and the like. In the two years the department has been established it has assisted in locating over two hundred industries in advantageous places, a record which indicates the value of the service such a department can render when it has been completely organized.

Letters to the Editor.

State Control of Water Resources.

Sir: The value of water as a natural resource seems to be just becoming appreciated by the State Legislatures of this country. With the realization that forests are disappearing and that industries and population are rapidly increasing, they are beginning to see that the waterways are becoming reduced in value, and that just as it is necessary to protect and preserve the great forest areas, so is it necessary to preserve and properly distribute the waters.

In certain Western States, where the value of agriculture depends largely upon irrigation, the water within their boundaries has been quite generally recognized as of enormous value, and, consequently, legislation has been enacted providing for its distribution and use. Administrative and executive bodies have been created by these States, in whom the absolute control and distribution of the water resources has been vested. In the establishment of these bodies, provision has also been made for careful hydrographic surveys, and the investigation of the water supply.

Apparently, only a few of the Eastern and Central States have begun to recognize the value of this natural resource. New Jersey was, perhaps, the first State in the East to make a careful study of its water resources, and a valuable report was published by the New Jersey Geological Survey in 1894. In this report are published observations of the rainfall and the flow of all the principal streams and many of the minor ones, the routes followed, reservoirs, sources of supply and quantities of water used by the canals of the State, together with the water power developed on the several streams and canals. This body, however, had no power over the distribution and preservation of the water, being, as it was, merely an investigating body. Later, a State Riparian Commission was appointed to regulate and control the use of the waters of the State, and in March, 1906, the State Potable Water Commission was created, to control and preserve the purity of the potable waters.

Many of the streams of New York State have been thoroughly studied by the various canal commissions and local commissions. In 1904 a State River Improvement Commission was created to regulate the flow of rivers in aid of safety and public health. This State has had for a little over a year a State Water Supply Commission, created in order to insure an equitable distribution of the waters of the State, and to preserve the various financial interests which may be affected by the use of waters of various streams, etc.

Massachusetts has had a Metropolitan Water Board for many years, its jurisdiction extending over only that area which lies within a radius of 10 miles of the State House, at Boston. This body was created to obtain and preserve a pure water supply for this Metropolitan district.

The United States Government, through the Division of Hydrography of the United States Geological Survey, has for many years been making systematic measurements of the flow of many of the streams of the United States, and when this study is taken up by the State Governments, they will be greatly facilitated by the work which has been accomplished throughout the country by this organization.

Many of the States have boards of health, created to preserve the purity of the waters, but it appears that until 1905, New York and New Jersey were the only States, excepting where water is of great value for irrigation purposes, which had executive bodies created for the purpose of studying and controlling the distribution of the water.

In April, 1905, the Pennsylvania Legislature enacted a law creating the Water Supply Commission of Pennsylvania. This body consists of five members, three of whom are appointed by the Governor and serve for a term of four years, while the Health Commissioner and Forestry Commissioner are ex-officio members. In this commission is vested the power to approve or refuse all charters for proposed corporations involving the use of the waters of the State, and to investigate the water resources of Pennsylvania, with a view to its equitable distribution, and the preservation of its purity.

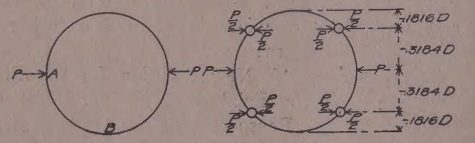
The engineering work of a commission of this nature is necessarily broad, and its organization and systematizing, a considerable problem. The commission must know, in order to judge fairly as to the equitable distribution of the water, the amount available, and its location with respect to centers of population and industry. This necessitates an extended knowledge of rainfall, topographic and agricultural conditions, of the flow in the streams and of the quantity of water used, etc.

As the population and industries grow, the demand for water increases, and even in a State so well supplied as Pennsylvania, many very nice questions arise as to the proper custodianship of the water. Sometimes it is a question between commercial and domestic consumers, and sometimes a decision must be made between two cities or villages. It is to be hoped that others will follow the lead of these States, in putting the distribution of this great and immensely valuable natural resource into the hands of Commissions which will faithfully preserve and wisely distribute the water to the users, who are, by virtue of location and need, its rightful custodians.

Yours truly, Farley Gannett, Engr.
Water Supply Commission of Pa.

Stresses in Horizontal Circular Girders.

Sir: In your issue of June 9th, Mr. C. E. Day gives a method for finding the bending moment, etc., in a horizontal circular girder under horizontal loads at different points around the circumference. It seems to me that in a circular girder of any considerable size, as in the case cited, for a tank, a designer would scarcely make the girder continuous for the complete circumference. It would be simpler to make the girder in arcs equal to the length between posts. In this case the bending moment is very simply found by resolving the normal force into two components in the direction of the sides of a regular polygon. The bending moment is then equal to one of these components into the versed sine of the arc which the side of the polygon subtends.



The solution of the problem which Mr. Day gives is found in Greene's "Structural Mechanics" for the case of two opposite forces, and in the writer's book of "Tables," page 49, this case is cited. The bending moments at the point of application of the force and at the quadrant point are given. In the first accompanying figure, letting D be the diameter of the circle, the bending moment at A is $0.1592\ P\ D$, and at B $0.0908\ P\ D$. The bending moments in the second case are lettered on the diagram. From the figure it is seen that the ring may be considered as hinged at four points (the points of inflection). Any number of pairs of forces may be superposed and the moments combined.

The combinations made by Mr. Day for bending moment due to four loads and six loads do not seem to be right. The writer obtains:

$H\ R\ (2/\pi - \tfrac{1}{2} \sin a - \tfrac{1}{2} \cos a)$ for four posts and $H\ R\ (3/\pi - \tfrac{1}{2} \sin a - \tfrac{1}{2} \sqrt{3} \cos a)$ for six posts, instead of the values given by Mr. Day.

Yours very truly, Edward Godfrey.
Pittsburg, June 13.

Local Prevailing Prices.

Sir: What do you understand by "local prevailing price?" I have built a septic tank below ground for one of my clients and made a contract with him to do the whole job for $250. This tank was located about 6 ft. from the house. Rock blasting had to be done and I had a clause in the contract with my client saying: "rock blasting, if necessary, to be done at the local prevailing price." Being an engineer myself, I sublet the contract and conferred with the sub-contractor about the rock blasting. He thought, it being so near the house, it would be best to take only a very careful blaster, and, furthermore, advised me to have the blasting done by day's work to insure that the work be done slowly and carefully, so that the house would not be damaged. He said he had a very careful man on hand and I told him to take him. We agreed on $2.50 per day per man, $2.25 being the local prevailing price for blasters per day, and $0.25 for him for administration. As it happened, the blasters unexpectedly struck water; and two men had to pump all day to enable the blasters to do their work.

It being so near the house, the blaster had to blast in very small quantities, and therefore to drill more holes than under ordinary circumstances, which again required more dynamite and more time. It took them about two weeks to do the job, which would have under ordinary circumstances only taken about one week. The bill for blasting, therefore, amounted to $112 for about 20 cu. yd. of rock excavation, which is, of course, an unusually high price. When it came to paying the bill my client refused to pay the high blasting bill, blaming me for not letting this job per cubic yard instead per day's work, saying that he and his lawyer understood under "local prevailing price" always per cubic yard. I stuck to my contract, saying that he agreed to pay the rock blasting at the "local prevailing price," and as we (considering the nearness of the house, etc., as previously mentioned) chose to sublet the blasting by day's work, he had to pay just the same.

Who is right? Is it necessary to understand under "local prevailing price" in this case only the price per cubic yard, or is not $2.25 per day per blaster just as well the "local prevailing price." Any information you can give will oblige,

Very truly yours, Wm. H. S.
New York, May 29.

[The Engineering Record has vainly endeavored to find some precedent on this point. Any reader having information concerning it is requested to furnish it for publication.]

A Producer Gas Engine Plant in the municipal lighting station at Algona, Ia., has been tested by the mechanical engineering department of the Iowa State College. The engine was a three-cylinder vertical machine rated at 150 b.h.p. at 250 r.p.m. and, like the producer, was built by the Fairbanks-Morse Co. Anthracite pea coal was used at the rate of 1.511 lb. per brake-horse-power when the engine was developing 40.1 h.-p., 1.157 lb. at 82.7 h.-p., and 0.999 lb. at 156.9 h.-p. This is equivalent to a fuel charge of 4.53, 3.47 and 2.99 mills per brake-horse-power, with coal at $6.